PB81-242497

Research Highlights, 1980

(U.S.) Environmental Protection Agency
Washington, DC

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This document describes accomplishments made by the Office of Research and Development in 1980. It also illustrates how the Office of Research and Development's research helps people--helps to keep them healthy and to be more productive.

Research areas covered in this year's Highlights include: environmental emergencies, hazardous waste disposal, standards, air pollution, wastewater, energy, oil and gas from coal, health effects, modeling, new technology, and integrated management.

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FOREWORD

The effects of pollution cost this nation tens of billions of dollars per year. This cost is paid in terms of sickness, medical bills, absenteeism, and sub-optimal performance. It is paid in terms of the advanced equipment necessary to process much of our drinking water. It is paid in terms of the damage to homes, paint, buildings, and monuments caused by acid rain. It is paid in terms of the human suffering and lost real estate values caused by abandoned waste sites. It is paid in terms of the food fish that our rivers cannot nourish, the recreation spoiled by effluents, and the beauty obscured by industrial haze.

The Environmental Protection Agency defines standards, criteria, and regulations to reduce the cost we must pay for pollution. These regulations have their own costs—especially in terms of additional control technologies and special handling of effluents. Thus, it is in everyone's interest to keep both costs—the cost of pollution damage and the cost of pollution control—as low as possible. To do this requires an enormous amount of precise scientific data and expertise. As you will discover from reading this year's Research Highlights, the scientists and engineers of EPA's Office of Research and Development provide much of this data and expertise in several ways:

First, we provide a cadre of specialized scientists who produce, review and/or evaluate the Agency's regulatory actions. Such actions help to assure that EPA's regulatory decisions are sufficient, practical, and based upon the latest scientific information.

Second, we make available to the EPA and to the federal government an entire spectrum of technical and managerial expertise for such environmental emergencies as Love Canal and Three Mile Island.

Third, we develop many of the technologies which make pollution control feasible, and work to reduce the cost and energy consumption of existing technology.

Fourth, since our scientists and engineers publish more than 500 articles in the scientific literature each year, we help to establish the credibility, quality, and objectivity of the data upon which EPA's regulatory actions are based.

The activities described in the 1980 Research Highlights illustrate all of these types of activities and more. They also illustrate how our research helps people—helps to keep them healthy and to be more productive. For example, we helped the people of Georgetown, Texas to avoid the recurrence of an illness which had struck thousands of them last summer. We designed a system to protect the citizens of Islip, New York from hazardous air pollutants being emitted by a nearby dump. The people of Windham, Connecticut have a more secure water supply because one of our projects sealed a dump whose leachates were threatening the town's reservoir. We sent sophisticated cleanup equipment to more than a dozen textile plants to help their owners test alternative pollution control technologies. And we helped corn and onion farmers to produce more pest-free crops at less expense.

I trust that in reading this year's Highlights you will share our sense of pride in the accomplishments of the past year, and our optimism about finding solutions to the problems of the future.

Richard M Dowd

Richard M. Dowd
Assistant Administrator
for Research and Development
(Acting)

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EMERGENCIES

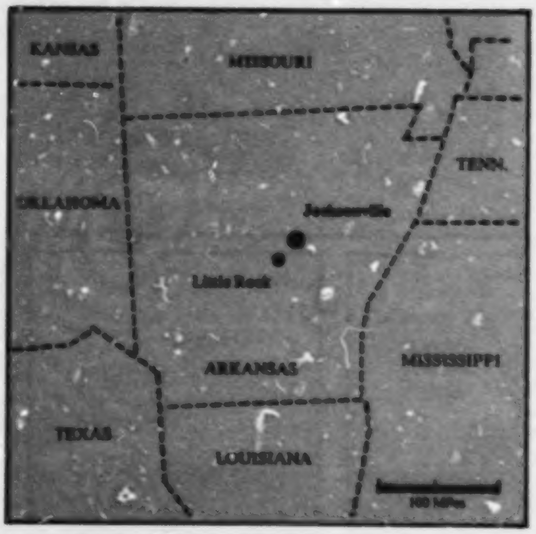
EPA researchers respond to
a variety of
environmental emergencies.

Because of EPA's research facilities and expertise, we are often called upon by other parts of the Agency to investigate emergencies which threaten human health or environmental quality. At short notice, we can and have moved sophisticated, state-of-the-art research techniques out of the laboratory and into local communities. Not only does this assist the community, but it also helps us to test out our own techniques—prove them in the front lines of some of the country's most serious environmental emergencies.

In 1980, our assistance in emergencies involved surveillance and monitoring, identification and analysis, and consulting and cleanup.

Jacksonville, Arkansas

Using aerial reconnaissance, EPA researchers were able to respond quickly to a request to determine whether a pesticide plant in Jacksonville, Arkansas, was experiencing a serious waste disposal problem. It had already been established that the facility was releasing dioxin—a highly toxic by-product of pesticide production—into the neighboring environment. An abandoned trench near the plant, which may have been used for a waste disposal site, had been covered over and houses built on top of it.



The reconnaissance aircraft was flown at a low altitude and produced revealing and detailed color photographs. Analysis of the photographs identified an active waste dump estimated to contain 3600 drums of toxic wastes. Also evident from the photos was a buried waste dump, detected by the presence of leachate which had percolated to the surface and was making its way to an adjacent stream.

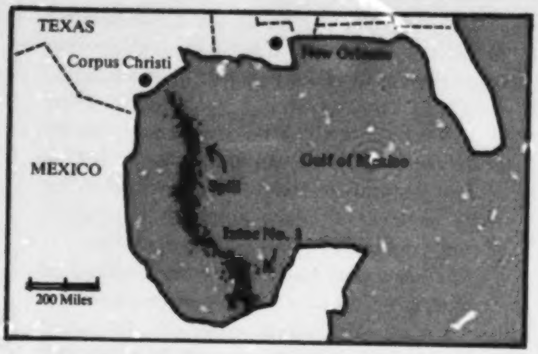
Following verification of the waste disposal problem, we then studied historical photos of the area taken at three- to five-year intervals beginning in 1937 and continuing through 1970. These photos enabled analysts to trace the development of the site from farmland and woodlots in 1937 to its less pastoral use today. Also revealed in the study were three other areas on the plant's grounds that may be in use as waste dumps.

This successful historical review method of determining the location of past waste dump sites will become increasingly important. As buried drums rust through, discarded chemicals will begin to appear in water supplies or on the ground's surface, penetrating inadequate disposal pit coverings. The fact that many past dump sites cannot be located in the records of sometimes-defunct landfill operators or even in current chemical company records makes the aerial detection technique one of the few viable methods for identifying problem dump sites *before* chemical dangers become manifest as human tragedy. As a result, in part, from such EPA research, the Jacksonville, Arkansas chemical facility is currently under litigation and under a temporary restraining order.

Ixtoc I Oil Spill

On June 3, 1979, a major blowout occurred on the Ixtoc I oil platform, a Mexican-owned offshore drilling installation in the Bay of Campeche. Oil spewed into the Bay, quickly spreading into the Gulf of Mexico and, finally, by August, reaching the Texas coastline at the height of tourist season. The oil company was unable to cap the well for 10 months, during which time the oil continued to gush out into the Gulf's waters.

Aboard the EPA vessel *Antelope*, EPA scientists and the EPA Region VI response team took part in a massive multi-agency effort to measure the spill and gauge the environmental effects of the oil on the Texas coast and near-shore waters. Water column samplings of the suspended oil were taken, and preliminary trawl mappings of bottom deposits were conducted through August and September. Preliminary results indicated that in the deep waters of the Gulf damage was minimal but when the oil reached shallow waters it became incorporated into the sand bars, or found its way to the beaches and surf zone, that area between the low tide level and the farthest line of breaking waves. It was also shown that certain marine organisms were being harmed by tarballs from the spill. More recent surveys indicate that the beached oil is now concentrated in the surf zone and that probably little oil will be found further than one to two miles offshore.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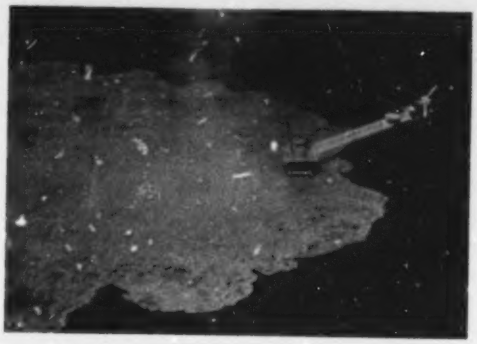
New Orleans
MEXICO
Gulf of Mexico
Spill
Ixtoc No. 1
200 Miles



The burning Ixtoc I well spreads oil in the Gulf of Mexico

It is expected that the ongoing analysis of the numbers and types of organisms collected in the trawl mapping of the survey area will yield an approximation of the impact of the spill on near-shore fauna.

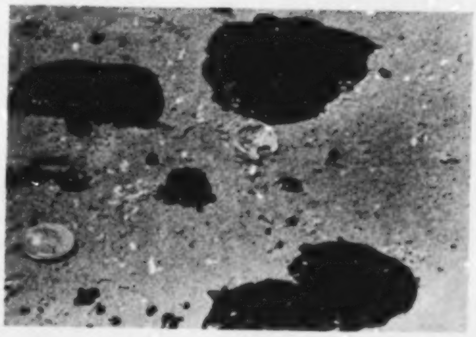
During the height of the spill threat, EPA researchers were also involved in:

- aerial overflights to assist in the discrimination of oil from other debris, and to determine potential interactions between the oil and seabirds or mammals;
- preparing biota/sediment/microbiological and petroleum samples for reference specimens or archiving;
- deploying tracking devices to determine the rate and direction of oil spill drift.

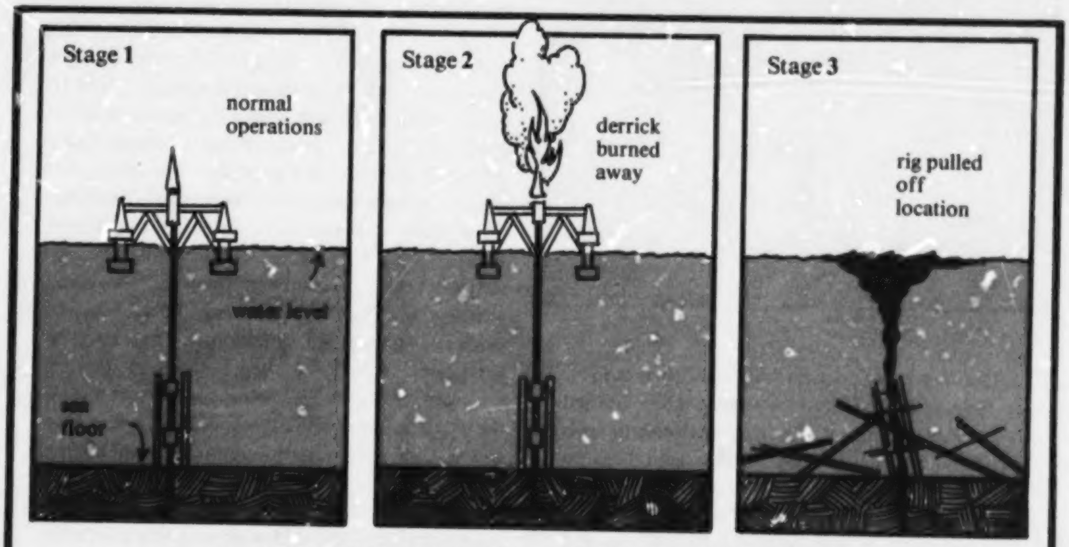
In addition, we took part in the preparation and review of a variety of reports that stemmed from the spill response and a critique of the Ixtoc scientific support effort.

The well was capped on March 20, 1980, and the international concern over its immediate effects abated. What long-term impacts the spill may have, however, are still to be evaluated.

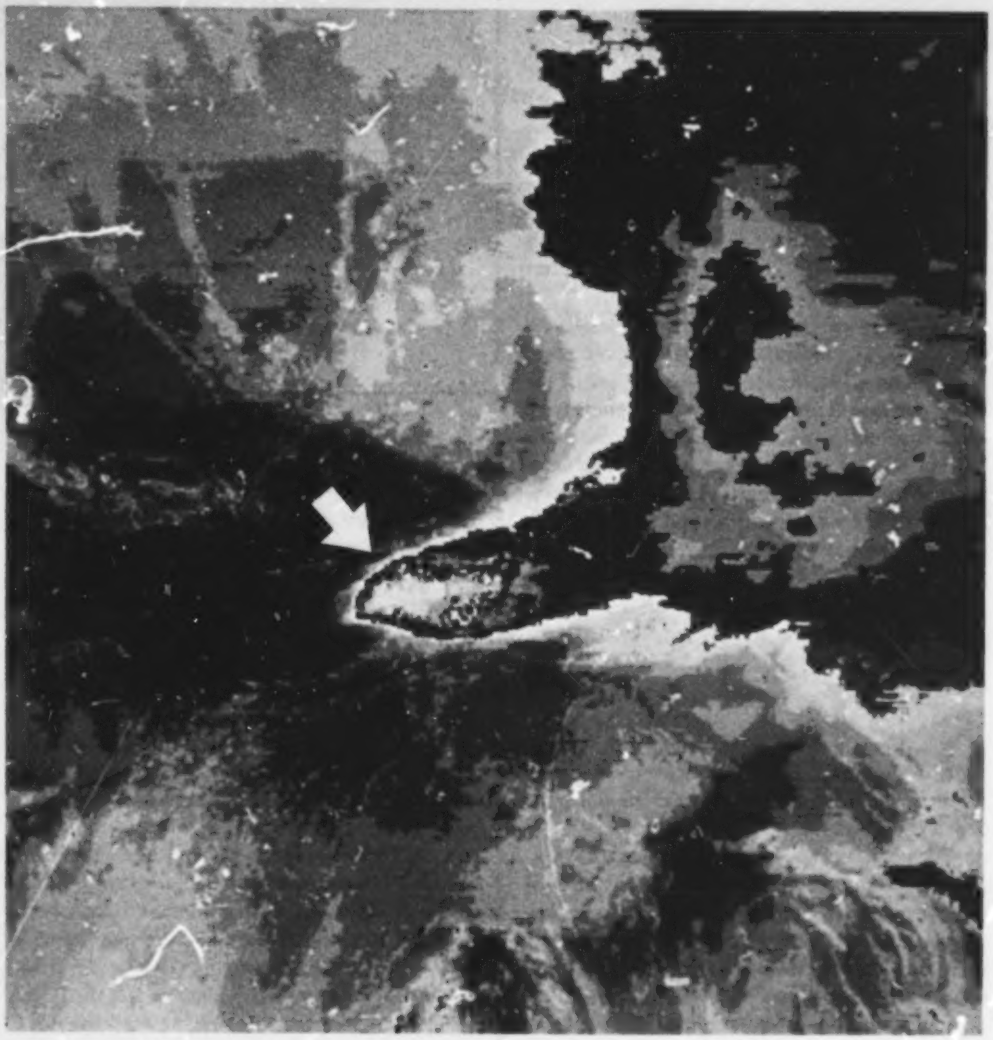
Cleanup crews survey oil from Ixtoc I on the beaches of Texas



Tar balls on the Texas beach


Stage 1
normal operations
water level
sea floor
Stage 2
derrick burned away
Stage 3
rig pulled off location

SEQUENCE OF IXTOC OILWELL BLOWOUT



On black and white thermal imagery, hotter areas are whiter and cooler areas darker. In the thermal image of Mt. St. Helens, the bulge was clearly hotter than its surroundings.

Mt. St. Helens

More than a month before the spectacular eruption of Mt. St. Helens in Washington state, EPA's Office of Research and Development was asked to plan and carry out a series of aerial reconnaissance flights over the mountain's crater and surrounding area. The flights had two objectives: First, using conventional aerial photographs, to assess damages to the area by comparing pre- and post-eruption photographs, and second, using images from a thermal scanner (a device that detects and "photographs" heat emitted from objects) to pinpoint the mountain's hot spots—the areas with high potential for volcanic activity. The first flight was flown over the mountain and down into its crater on April 10, 1980 following early volcanic rumblings. The EPA aircraft was equipped with the thermal scanner and with cameras containing color infrared film. The imagery results showed numerous hot spots on the mountain including many at the site where the major eruption eventually occurred.

A month after the first flight, on May 9, a plug in the throat of the volcano's crater violently discharged, marking the second stage of the volcano's eruption. Within two days, a patch of hot rocks formed an enormous bulge on the volcano's north slope, protruding now 320 feet from its former configuration. Finally, on May 18, the long-expected major eruption occurred near the bulge. Nearly 1000 feet of the volcano's top was blown off, blasting mud, ash, and rocks into nearby Spirit Lake and the Toutle River Valley. EPA's aerial photography team was on the scene again, documenting the event.

The final EPA reconnaissance effort on May 31 revealed the extent of the damage. Flights along the waterways in the area showed that new drainage patterns were being established along the altered topography, new channels were cutting into the mud slides of the Toutle River, and steam vents, sulfur puddles, and the deluge of mud were clearly evident throughout the area. The scope of the disaster around Spirit Lake and a fruitless search for a former resort lodge were photographically documented.

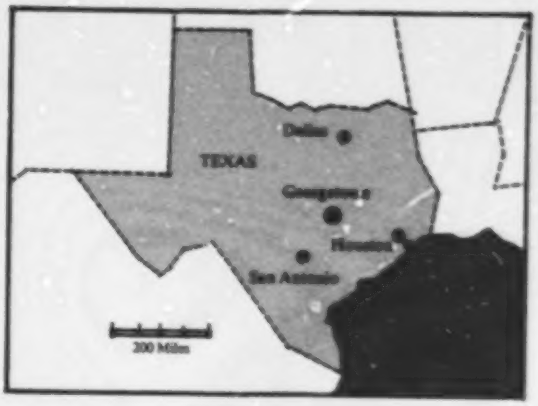
All of the EPA-gathered data was subsequently made available to the U.S. Geological Survey and the Department of Energy to aid in their volcanic activity studies and planning. Such information will play a role in science's ability to better understand volcanos and future eruptions.

Massive reseeding of the area is underway to prevent additional mud slides during the rainy season, and a 24-hour dredging operation of the Columbia and Cowlity Rivers is in progress, to be completed, it is hoped, in time to handle the surface runoff. Abetting human efforts to stave off further disaster is a natural one: Four months after the eruption, vegetation and trees could be seen starting a new growth through the volcanic ash and mud.

Georgetown, Texas

On June 18, 1980, a preliminary survey in Georgetown, Texas conducted by the Texas Department of Health indicated the possibility of a waterborne disease outbreak. Of 100 persons interviewed, 70 were afflicted with diarrhea, stomach cramps and nausea, results typical of such an outbreak. The survey also indicated that the peak of the illness occurred on June 13 and that the outbreak was probably subsiding. Still, officials felt that it was of prime importance to document whether the outbreak was waterborne, determine its probable cause, and implement corrective measures to prevent recurrence of the illness.

On June 19, the EPA research office was advised of survey results and by the 20th an EPA engineer was in Georgetown to join a team of two physician-epidemiologists and a statistician from the Center for Disease Control. An evaluation of the city's water system was undertaken. It was found that there were seven wells serving the affected community, that there were three primary zones of water distribution with several areas in the distribution network receiving a mixture of waters, and that chlorination facilities at the well sites were not adequate. The evaluation also revealed a sewer line passing within 25 feet of two wells which primarily served the southern portion of the distribution system. From this information, a random household survey was designed.



While this survey was in progress, efforts were made to determine whether the sewer line was influencing the wells. Scan by television camera was attempted, but the six-inch sewer line was not large enough to admit the camera. Dye-testing of the sewer failed to produce any increase in fluorescence in well waters, and excavation of the line did not reveal any significant leakage. Samples of water collected from two of the wells did show, however, fecal coliform contamination in excess of 1200 colonies/100 ml, indicating that groundwater was indeed being influenced by human or animal wastes.

Results of the random household survey reinforced the findings that were accumulating from the water system evaluation. Epidemiological data showed attack rates of those persons residing in areas served by the suspect wells to be significantly higher than in other parts of the city, a finding further reinforced when data was refined to correct for those living in one zone and exposed to water in the zone of high illness through work, visiting, etc. Applying attack rates established in the survey to the community population, it was estimated that probably 8000 people had been affected by the illness during the outbreak.

Still, despite the extensive water system evaluation and the epidemiological survey, the team was unable to pinpoint the exact source of the contamination. City officials, however, responded quickly to implement EPA recommendations to improve the water system. New chlorination equipment was installed to improve reliability of operation, and sampling of the system was revised to better define microbiological and chemical water quality. The city also applied for emergency HUD funding to implement EPA recommenda-

City officials responded quickly to implement EPA recommendations

tions for increasing chlorine contact time, and was awarded $800,000 for construction of contact tanks and addition of ancillary equipment.

An extensive monitoring of the wells in and around Georgetown to establish the contamination sources is ongoing under the auspices of the Texas' State Department of Natural Resources.

Three-Mile Island, Pennsylvania

On Saturday, June 28, 1980, the controlled venting of 43,000 curies of radioactive krypton gas (^{85}Kr) was initiated at the Three-Mile Island nuclear power plant by the plant's owner, Metropolitan Edison Power Company. The venting of the plant's reactor containment building was to be a vital first step in its eventual decontamination. On-site that Saturday were a number of EPA research personnel, scheduled to remain at or near the facility to perform a variety of monitoring, analytical, and public information duties throughout the venting procedure.

The direct venting of the krypton into the environment under controlled conditions was approved by the Nuclear Regulatory Commission (NRC) and endorsed by the Pennsylvania governor, but not before a number of alternatives were weighed.

Ultimately, however, the direct venting approach was adopted when federal and state agencies concluded that no radiation-induced health effects would result from the low levels of exposure to krypton that the controlled procedure would involve.

Four minutes into the procedure, however, the venting was terminated when there was an indication that the alarm level on the stack monitor had been exceeded. Investigation of the device proved this to be a calibration problem. The alarm level had been set to measure particulate radioactive material, not the radioactivity associated with the venting of krypton gas. Venting was resumed on Sunday, June 29.

Compressed gas samples collected on Sunday and Monday showed krypton concentrations ranging from background to approximately 1500 pCi/m^3, corresponding to 0.5% of the standards. The venting continued on a 7-day, 24-hour basis for 15 days until the krypton concentrations within the building were reduced to acceptable levels. Continuous monitoring by EPA revealed that krypton exposures in the vicinity never exceeded the applicable standards; in fact, the highest levels recorded were on day 12 of the venting when a level of 85,000 pCi/m^3 was recorded at the Observation Center monitoring station.

July 12 marked the end of the venting procedure, after which plant personnel entered the building to assess the extent of damage and to establish a schedule of further decontamination and cleanup activities. As this schedule evolves and as more cleanup and decontamination activities take place, EPA's in-place monitoring network and on-site team will be supplemented by our monitoring experts. An EPA report of its involvement and findings at the power plant site is being prepared for publication in the technical literature.

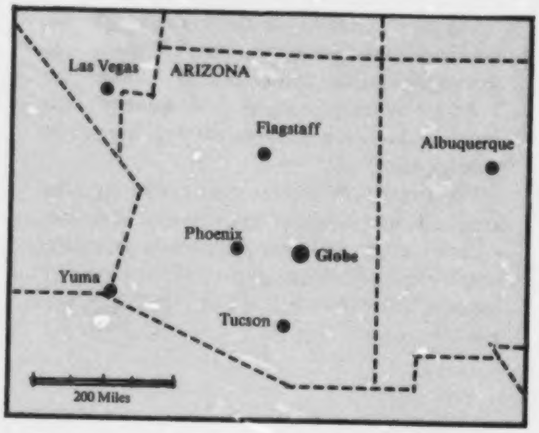
Globe, Arizona

Late in 1979, active and abandoned asbestos mine tailings were discovered in and around the city of Globe, Arizona, some 70 miles east of Phoenix. Subsequent soil samples collected by Arizona officials indicated high levels of asbestos. The officials did not possess the tools, however, to determine the amount of the contaminant that had already been or continued to be scattered by the wind or transported by surface water runoff. Following the sampling, the governor of Arizona issued evacuation orders for all homes built within three miles of the tailing piles.

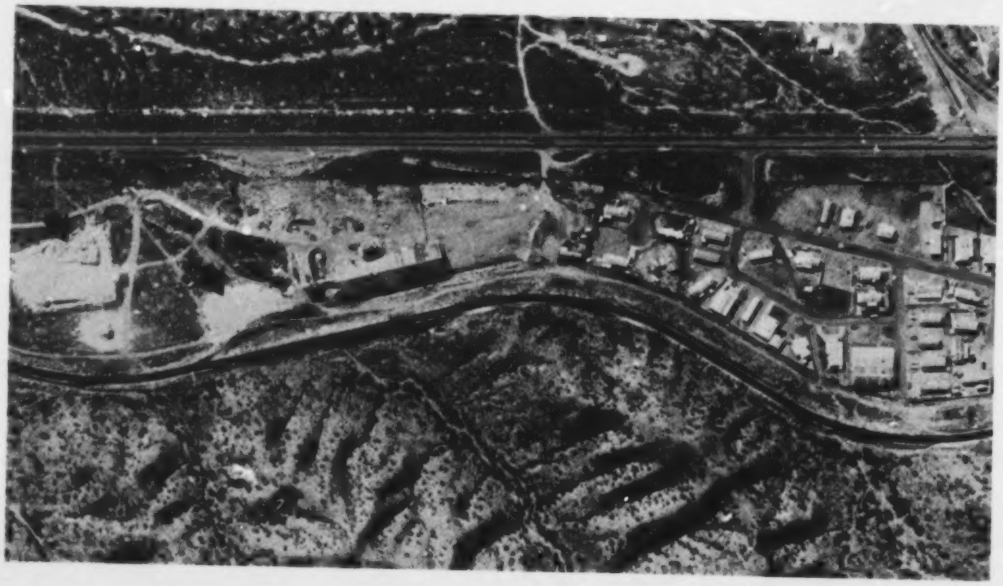
Called in to provide assistance in the evaluation of plans for the asbestos cleanup, EPA requested our support in the form of an aerial photography and reconnaissance flight over the Globe area and the nearby town of Miami. Beyond providing a much needed map of the town's residential area, it was expected that the aerial imagery would aid analysts in determining wind transport and surface drainage patterns; in identifying the extent of the tailings; and generally in evaluating mining procedures. The flight took place on Sunday, December 30. By Monday, New Year's Eve day, EPA researchers had processed the film, and the color prints were in the hands of EPA and Arizona officials involved in the emergency.

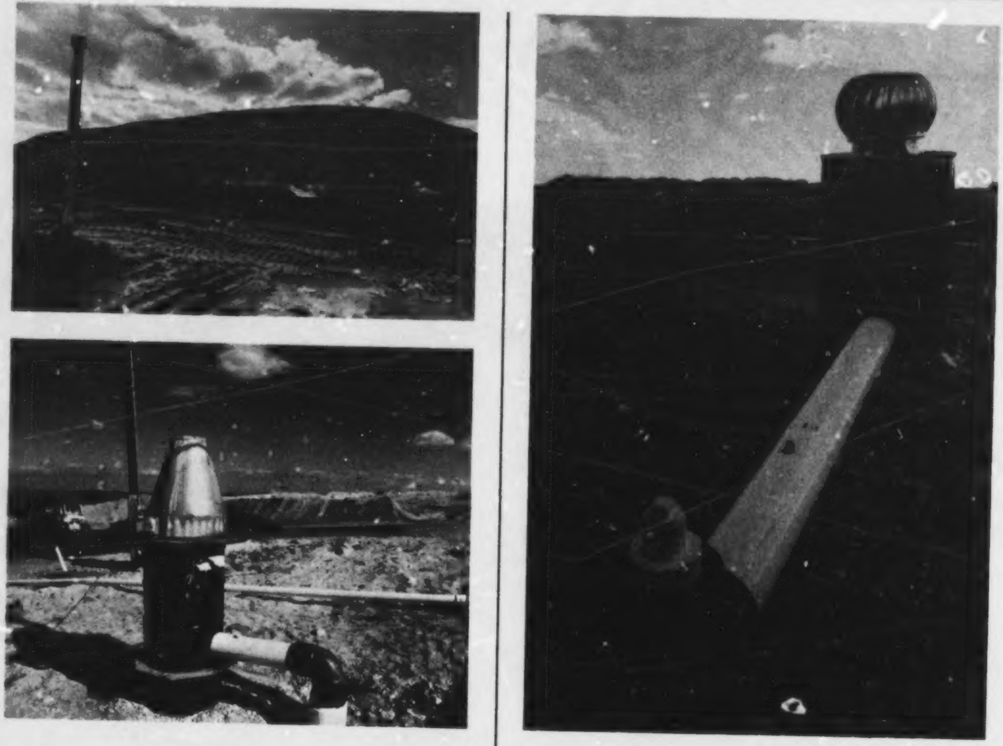
The December photo coverage was not entirely satisfactory, however. Due to the excessive moisture in the air and on the ground, an accurate representation of asbestos tailings being transported by the wind could not be determined. Thus, another series of overflights was flown on May 28, 1980. This time, in addition to the standard aerial photographs, a multispectral scanner was carried on board the reconnaissance plane. The scanner was fitted with a detector sensitive to the part of the spectrum—2 to 2.5 microns—at which asbestos tailings can be best identified. Although somewhat experimental in nature in that the identification of asbestos in that spectral range had only been shown in laboratory studies, the imagery that was produced indicated that several areas in and around the city of Globe had image signatures characteristic of asbestos tailings. Computer-enhanced digital images of the signatures were compared to images of sites with known surface materials and asbestos concentrations. In this manner concentration levels in Globe were ascertained.

EPA's emergency assistance in troubled Globe made possible a full assessment of the dangers posed by the asbestos tailings and ultimately helped in tracking the pollutant as it worked its way through the soil, the air, and the water. Subsequently, the tailing piles have been covered and one of the mills near a trailer park has been dismantled.



Asbestos tailings in Globe are next to a public school and homes





Three different types of vents protrude from the Islip landfill

Islip, New York

On July 21, 1980, the EPA research and development office received a request for emergency assistance in the town of Islip, New York, where an active municipal landfill was found to be emitting unacceptable levels of vinylchloride monomer (VCM) from several of its gas vents. Air samples taken with a portable gas chromatograph at nineteen of these vents had indicated VCM concentrations of up to 90 ppm, fully *nine* times the national emission standard for hazardous air pollutants.

The EPA mission at Islip was to provide a temporary, remedial fix to protect residents—some with homes as close as 600 feet from the vents—until the state of New York could complete closure operations and cap the landfill. A school house, also in close proximity to the toxic gases being vented, had already been ordered closed by the township.

In the days immediately following the request, EPA scientists worked to find a suitable pollution abatement scheme. Four possible remedial measures were identified as potential temporary solutions. All were based on adsorption of the VCM onto granulated activated carbon. Of the four proposed, two were selected for on-site evaluation.

Preliminary worst case estimates of vinyl chloride emissions indicated approximately 11.6 g/hr (231 lb/yr) VCM from a single worst case vent, and 95 g/hr (1850 lb/yr) VCM from all vents.

By July 25, 1980, five gas treatment units had been developed, modified, and installed by EPA research personnel. Subsequent analysis of emissions from these units indicated that VCM concentrations had been reduced to below the detection limit.

As part of the same effort, EPA scientists are evaluating a proposed system of pumped vent-wells placed in the soil around the landfill to promote movement of methane, an explosive gas, outward from the landfill through the soil. Burners that would destroy both the methane and the VCM pumped from the vent-wells are also being considered.

The following EPA research components contributed to the research described above:

- Office of Monitoring and Technical Support—Environmental Monitoring Systems Laboratory, Las Vegas
- Office of Environmental Processes and Effects Research—Environmental Research Laboratory, Gulf Breeze
- Office of Health Research—Health Effects Research Laboratory, Cincinnati
- Office of Environmental Engineering and Technology—Municipal Environmental Research Laboratory, Cincinnati

HAZARDOUS WASTE DISPOSAL

As waste amounts increase and available disposal sites grow fewer, EPA researchers seek new disposal options and resource recovery measures.

In the past, we have often paid dearly for our ignorance of, or indifference toward, the environmental impacts of our activities. In no area is this more true than in the disposal of hazardous wastes. Among the factors that makes this problem so complex is that it involves so many different actors. Industries, agriculture, municipalities, the military, and even the individual must all at some time bear the brunt of making proper waste disposal decisions.

But what is proper? And, of the thousands of substances in commerce, which pose hazards? And under what circumstances? These are the questions faced by EPA researchers, working to provide the answers needed to prevent environmental calamities today and tomorrow, and to support effective action by those faced with the disposal of wastes.

Love Canal

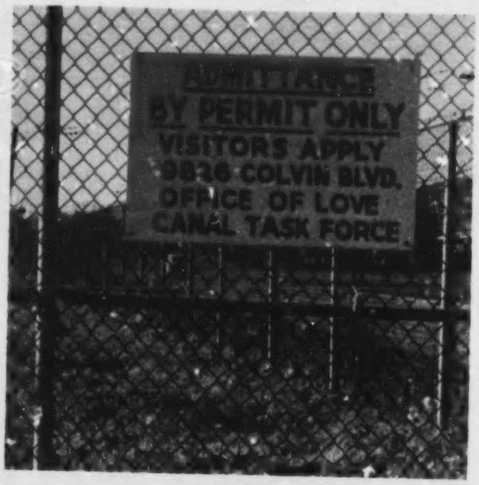
In the summer of 1980, the federal government declared a health emergency in an area approximately one square mile around Love Canal in upstate New York. EPA was charged with the task of going into the area to determine the extent of chemical contamination and possible human exposures to it. Local residents were given the option of relocating while the testing went on.

An elaborate multi-media sampling program was conducted, as was a hydrogeological survey. Samples of air, water, soil, sumps, sediments, and biota were taken, then analyzed for toxic materials. Primary responsibility for this effort fell to EPA's Office of Research and Development.

Perhaps as important as the testing itself was the relationship of the test personnel with Love Canal residents, who had much at stake, both in their homes and land and in the outcomes of the various tests being performed. For these reasons a great amount of time was spent by EPA research personnel talking with residents, explaining to them the reasons for specific tests, and possible test results. Most of the samples taken also required access to private property, with permission by local homeowners first having to be granted. In these instances arrangements were made to make sure that residents received reports of the test results.

As of this printing, the sampling program still continues, with results expected early in 1981.

Human Monitoring Program. Early in 1980, EPA was asked by the Justice Department to assess the extent of human exposure to hazardous chemicals in the Love Canal area. This was to be accomplished by obtaining blood samples from area residents and analyzing them for trace residues of some 55 chemicals, and for chromosome abnormalities in the circulative lymphocytes (a type of white blood cell). The chromosome study was extremely controversial in scientific, legal, and environmental circles, resulting in a recommendation that it be repeated. This is now being done under the guidance of the Center for Disease Control of the Department of Health and Human Services.



Fences surround Love Canal houses

The chemical compounds that were tested for, were chosen from among those known to have been dumped in the landfill and those found in a preliminary sampling taken by the state of New York of air from basements of houses surrounding the dumpsite.

Groundwater Sampling. EPA researchers were also called on in 1980 to determine the occurrence and quality of groundwater in the Love Canal area. The extent of the hazard posed to the groundwater supplies was to be determined, the precise location of any contaminant plume established, and its ultimate location predicted. Researchers also were asked to predict the eventual effects that any contaminant plumes discovered would have on the future of groundwater quality in the area.

Upon receiving the task, EPA employed an experienced contractor to oversee the drilling of the monitoring wells that would be required to complete the job. Other contractors were hired to collect geophysical data, analyze samples, and develop mathematical models of the aquifer flow systems. Also part of the preparatory work was securing permission from private homeowners for use of their property as drilling sites. EPA personnel obtained these necessary permissions, at the same time explaining to the residents the drilling and testing procedures that would take place.

After careful study, it was decided that each of the monitoring sites would have two wells, one about twenty feet deep and one about fifty feet

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Drilling rig taking core samples

Air sampling station

deep to sample both aquifers. Drilling methods that used mud or air were ruled out because of the possibility that they might disperse contaminants into the atmosphere or onto previously uncontaminated land. Instead, six auger-type drilling units—the type usually used to drill water wells—were selected to do the drilling. To avoid contamination from one well to another, drilling rigs were completely washed down after each well was completed. Throughout the entire drilling procedure, at least two EPA representatives remained on-site to provide technical information and assistance.

Protection of the workmen and other on-site personnel was given prime consideration

Protection of the workmen and other on-site personnel was given prime consideration. Physicals were given each person prior to beginning work on the project and following completion of the sampling study. Those involved with the drilling wore disposable coveralls, and respirators were worn around their necks to be used in case gases became present in the area.

Air Monitoring. A comprehensive indoor and outdoor air monitoring study was initiated by EPA at Love Canal. The sampling took place at 64 residences (60 at Love Canal and 4 background or control homes) and resulted in the gathering of more than 2500 air samples.

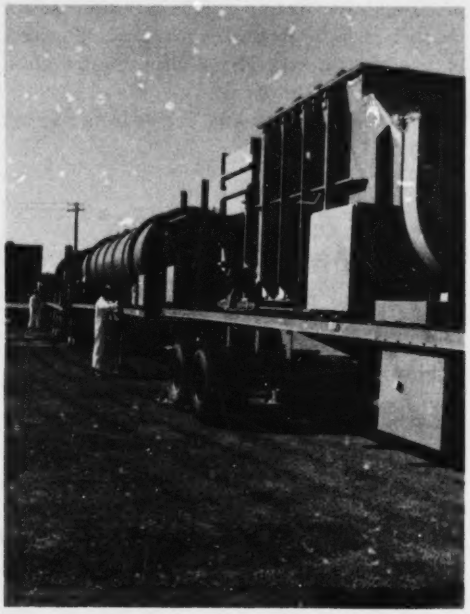
In all, 42 compounds were monitored at Love Canal. These compounds were either among those identified by a 1978 New York state survey, among those found in the Love Canal sewer system, or among those known to have been dumped at the Love Canal landfill. A qualitative survey was conducted for 23 of these compounds while a complete quantitative survey was performed for the remaining 19.

Samples were taken from basements, living areas such as kitchens, and outside the house. The air was monitored for 12-hour periods at 5- to 8-day intervals. A total of 13 daytime sampling periods for each residence took place between August and October, 1980. Three additional 12-hour night sampling periods were also conducted to determine day and night variations. Many of the sampling and analytical procedures utilized were developed by EPA researchers and specially adapted for the Love Canal site.

The results of these monitoring activities will be released early in 1981 and summarized in next year's Research Highlights.

On-Site Cleanup

Drums containing chemical wastes are the ubiquitous symbol of past irresponsible disposal of industrial byproducts. The drums may be seen stacked by the thousands at "uncontrolled hazardous waste disposal sites" where waste chemicals may leak into the air, surface waters, and groundwaters, exposing the local population and ecology to actual and potential hazards such as fires, explosions, release of toxic gases and contaminated drinking water supplies.



The trailer-mounted mobile incinerator

Drum cleanup from such sites can be complicated and costly—a major cost being the chemical analysis required to support effective, safe disposal. In many cases, little recorded information is available regarding the contents or even the source of the drums. Unless information on the contents of many of the drums can be obtained by straightforward and inexpensive means, disposal of a large number of drums often comes down to one of two options: burn them or bury them.

Transporting the drums to a proper disposal facility to burn their contents, however, sometimes invokes both new hazards and public reaction, thus prompting consideration of on-site disposal options. One option is high-temperature incineration, and soon, as a result of EPA research, a state-of-the-art mobile incinerator capable of effectively destroying organic hazardous wastes will be available to perform the job.

This unique system, built to encourage commercialization and private use of the advanced incineration technology and designed for a rapid response, consists of three trailers mounted with a number of pieces of equipment. Included are a rotary kiln where materials to be incinerated are first volatilized to gases, a secondary combustion chamber for thermal destruction of the contaminant-laden gases, and an air pollution control train for removal of particulates and acid gases from the discharge gas stream.

1980 saw delivery of the mobile incinerator unit to EPA for final assembly and shakedown testing. The effort this year also included development of procedures for personnel safety and decontamination, analytical support, and other logistics. Yet to be developed, however, are methods for the safe preparation and handling of the hazardous wastes themselves, no doubt the key to the overall success of any future emergency cleanup operation making use of the system.

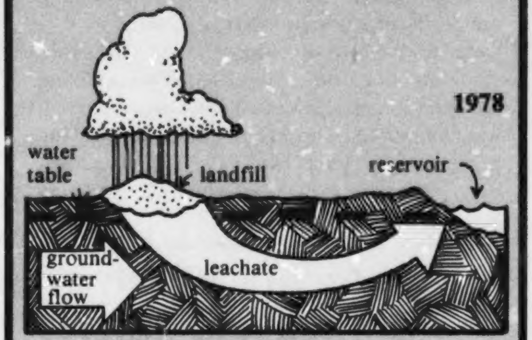
Field testing of the unit begins in the spring of 1981.

Sealing Waste Sites

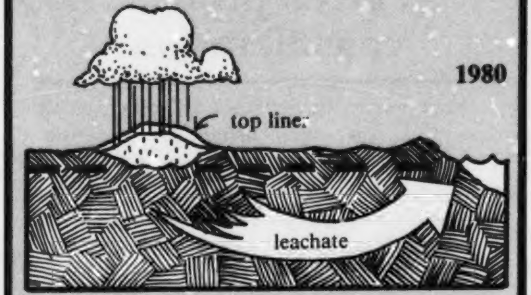
As many as a dozen of the state of Connecticut's 168 solid waste disposal sites are located in public watersheds. When rain falls on these landfills and seeps into the wastes, the resulting leachates threaten water supplies, human health, and the aquatic ecosystems found in reservoirs. The Windham dump is one such disposal site, located only 1000 feet from the Willimantic reservoir, source of drinking water for more than 16,000 people. At 22 acres, it is also among the state's largest dumps.

As early as 1974 when contamination of ponds between the disposal area and the reservoir could be observed, local officials were aware that a problem existed. A study concluded in 1976 bore out these observations and it was recommended at that time that the site be closed as soon as possible. By May of 1976, that recommendation became a mandate by Connecticut's Department of Environmental Protection, and in September of 1978 the site was finally closed. The problem of the remaining wastes being leached into undergroundwater supplies feeding the reservoir still remained, however, and it was not until an

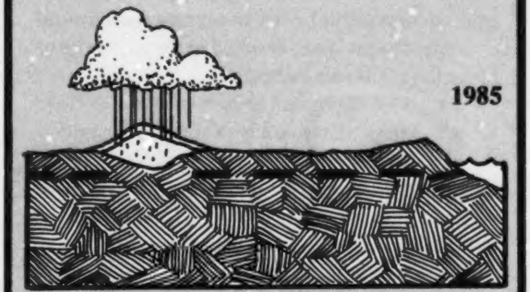
CROSS-SECTION OF WINDHAM DISPOSAL AREA



Poor top grading and cover soil, high infiltration of precipitation, leachate plume to reservoir.



Top liner prevents infiltration and new leachate production. Old leachate continues to flow to reservoir.



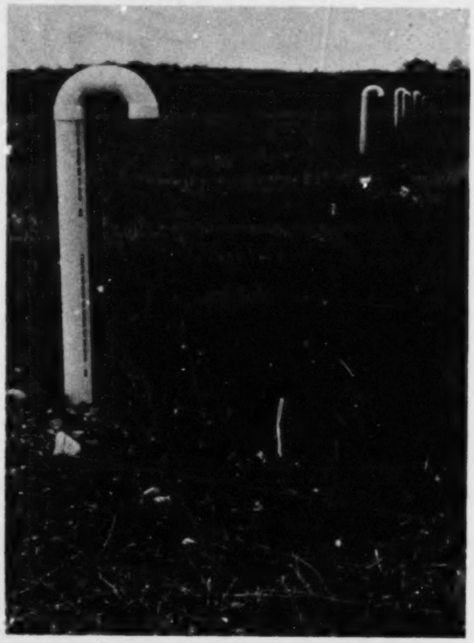
Liner remains intact, no new leachate forms, and aquifer flushes itself of leachates.

The Windham Reservoir. The landfill is beyond the trees in the background.

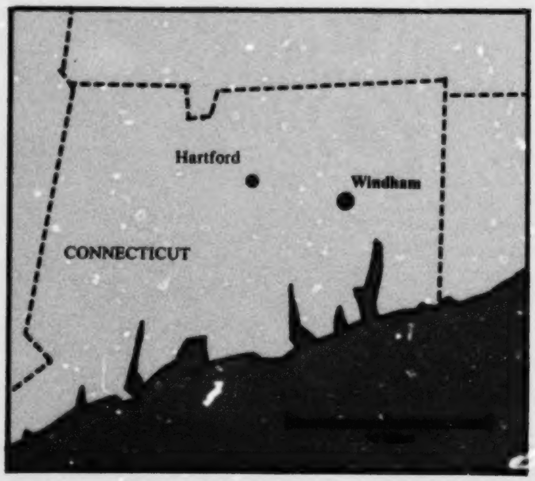
EPA-sponsored research project came to Windham that nearby groundwater quality was protected.

The research project, though, was not actually initiated with Windham in mind. Rather, it originated to demonstrate how, with proper closing and the use of existing technology, a landfill with serious leaching problems could be rendered harmless. The Windham landfill was eventually chosen as a demonstration site from among 400 candidate sites in 32 states.

EPA's solution to the Windham problem was a simple application of existing technology. A plastic cover or cap would be placed over the dump to seal it from precipitation. Actual installation of the cover—30 sheets of polyvinyl chloride measuring up to an acre apiece and weighing 5200 pounds each—was far less simple, however. First, refuse in the landfill, 25- to 50-feet deep, needed to be regraded to provide the proper runoff and to prevent puddles from forming in the plastic cover. Then the regraded landfill had to be covered with a foot of sand and gravel and a two- to three-inch cushion of silt to protect the underside of the 20-millimeter thick polyvinyl chloride sheets. A forklift truck was used to pull each folded and crated plastic sheet out to its full length and a crew of six men spread it out to its width, a relatively simple operation in perfect weather.



Vent pipes at the Windham landfill



But the Connecticut climate did not cooperate with the effort. As 1979 drew to a close, days grew cold and the plastic became rigid and difficult to flex. Breezes would wreak havoc with the sheets, catching in them as if they were sails, causing them to flutter wildly. The cold weather also interfered with the process of sealing the 30 sheets together. Still, by early December, the major work was done. The plastic was covered by a final foot of earth, which, in the spring of 1980, was enriched by the addition of composted leaves and local wastewater treatment plant sludge, then planted with grass seed.

As a project follow-up, a soil-moisture/groundwater monitoring network was installed to determine the effectiveness of the top seal. Project researchers anticipate that the cover will intercept up to 98% of the precipitation into the landfill, and that leachate generation will be so significantly decreased that it will no longer pose a threat to groundwater supplies.

Technical Data for Permit Writers

EPA implemented a hazardous waste permit program on November 19, 1980 and is now responsible for issuing permits for hazardous waste disposal facilities. It is also the Agency's task to provide assistance on the state of the art of disposal techniques so present sites do not produce future problems. To this end, hazardous waste disposal facility manuals are being prepared to aid in the review and evaluation of each permit application. These manuals contain the items that should be considered in the management of such a facility and include guidance for evaluating information for each item.

Yet, as permit applications processed by the EPA become increasingly complex, permit officials are finding the need for more in-depth references, ones that detail the various nuances of waste site technology. The technical resource document series established by EPA's Office of Research and Development in 1980 sets out to fill this need.

Supporting the Agency's hazardous waste management regulatory responsibilities, these documents describe and summarize available technical information and develop evaluation and design procedures where such information is lacking. This information can take on a number of forms. For example, some of the documents are designed to be used to predict the performance of the various components of a facility, (e.g. the amount of runoff from covers, the amount of seepage through bottom liners) without, however, specifying the acceptability of such performance levels, leaving this final evaluation to the permit writer. Other technical resource documents provide decision guidance for materials (e.g., liners, chemical fixation processes), and for design elements (e.g., drain spacing in leachate collection systems) while still others summarize significant technical factors and considerations without predicting performance or providing decision guidance.

Such documents, produced by EPA research, will become an integral part of the hazardous waste site permit issuance procedure because they provide a technical base for the preparation of revised permit manuals. They are expected to be valuable not only to the permit review official, but also to the designers and operators of prospective secure landfills.

The following EPA research components contributed to the Research described above:

- Office of Monitoring and Technical Support—Environmental Monitoring Systems Laboratory, Research Triangle Park
- Office of Health Research—Health Effects Research Laboratory, Research Triangle Park
- Office of Environmental Engineering and Technology—Municipal Environmental Research Laboratory and Industrial Environmental Research Laboratory, Cincinnati
- Office of Environmental Processes and Effects Research—Robert S. Kerr Environmental Research Laboratory, Ada

Rigorous research data enable pollution standards to be ecologically effective and economically sound.

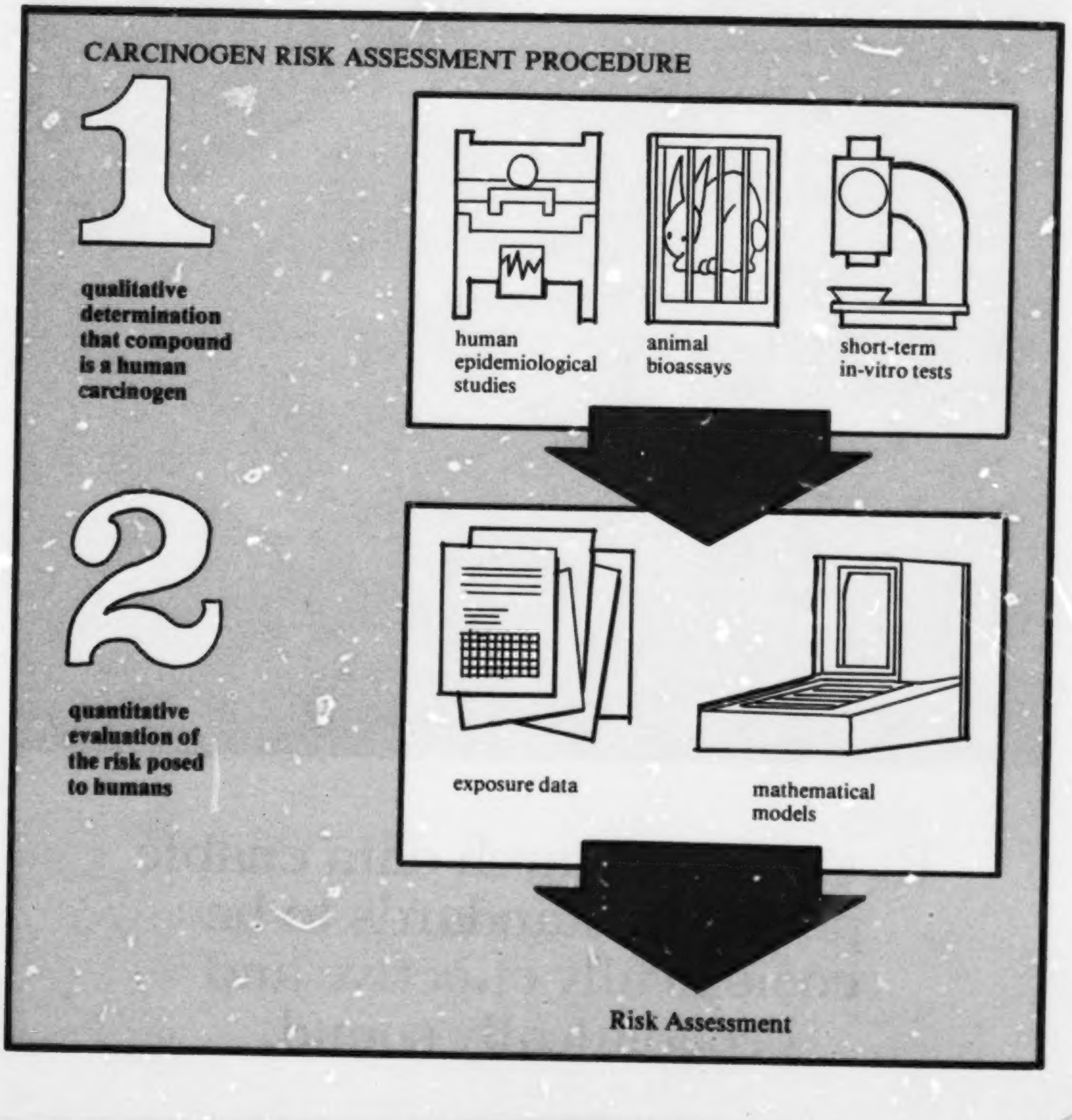
Arriving at appropriate environmental standards is often a long, complicated process. The completeness and credibility of existing scientific information about a pollutant must be established; questionable or outdated data must be discarded and new data must be generated where information gaps exist. Guidance must be provided to standardize analytical procedures, and guidelines must be developed to establish methods to interpret research findings. And only after the data is consolidated, considered, and, ultimately, is able to meet rigorous qualifications, can a standard be set. Following that, however, a review and revision procedure begins and the process starts anew.

EPA's Office of Research and Development is responsible for the research results that form the basis for much of the information that becomes part of the eventual standards. The 1980 highlights reflect both the breadth and depth of research data that is used for setting standards.

Cancer Risks

Today, one out of every four persons in the U.S. develops cancer. One out of every five dies from it. To decrease cancer risks, the current and widely held belief of many noted physicians, scientists, and researchers is that human exposure to chemical carcinogens must be decreased. EPA's research will help protect the population from the hazards that promote cancer. In 1980, results from that research were the identification of chemical carcinogens, and the estimation of risks associated with human exposure to them. These results provided the basis for the preparation of an EPA list of carcinogens as well as a number of risk assessment documents.

The assessment of health risks posed by a specific compound is a complex process involving, first, a qualitative determination that the compound is likely to be a human carcinogen, and,


CARCINOGEN RISK ASSESSMENT PROCEDURE
1
qualitative determination that compound is a human carcinogen
human epidemiological studies
animal bioassays
short-term in-vitro tests
2
quantitative evaluation of the risk posed to humans
exposure data
mathematical models
Risk Assessment

second, a quantitative evaluation of the magnitude of risk posed to humans by exposure to the compound in the environment. The qualitative part of the assessment involves the careful consideration of all available data from human epidemiological studies, animal bioassays, and short-term *in vitro* (outside the body) tests. The quantitative part of the assessment uses exposure data coupled with data from human epidemiological studies and animal bioassays, and various mathematical models to provide estimates of the probability that an individual might develop cancer during his or her lifetime from exposure to the compound. These data and procedures make possible the development of a range of estimates that define the impact of the compound for an exposed population.

Risk assessments are used by EPA to support regulatory efforts as defined by laws passed by Congress. One example of the use of risk assessments involves the registering of pesticides. Here, the assessments are used to weigh the benefits of a given compound against the dangers it presents. A second example is the use of risk assessment documents in deriving EPA water quality criteria. In this case, the qualitative portion of the assessment explains whether enough evidence exists to state that a given compound is a likely human carcinogen. If the evidence is sufficient, a quantitative assessment follows which defines at what concentrations in the water the compound would pose a relatively low risk.

One of the highlights of the 1980 risk assessment effort was the assessment of 2,4,5-T and it's contaminant dioxin, a component of Agent Orange, a herbicide used in Viet Nam as a jungle defoliant and now sometimes used as a spray in forestry management. The assessment included consultation with outside experts to review pathological specimens. Using this risk assessment data as a basis for action, EPA has subsequently proposed to cancel the use of 2,4,5-T in the U.S.

An adjunct to EPA's risk assessment responsibilities is the preparation of a list of carcinogens that is designed for Agency use in identifying chemicals of concern because of their carcinogenicity potential. Chemicals selected to be reviewed for inclusion on this list consist of those previously evaluated by EPA's Carcinogen Assessment Group and those evaluated by one or more of three organizations—the Food and Drug Administration, the International Agency for Research on Cancer, and the National Cancer Institute Bioassay Program, recently reorganized into the National Toxicology Program.

To be included on the list of carcinogens, a compound must first have been demonstrated to have either:

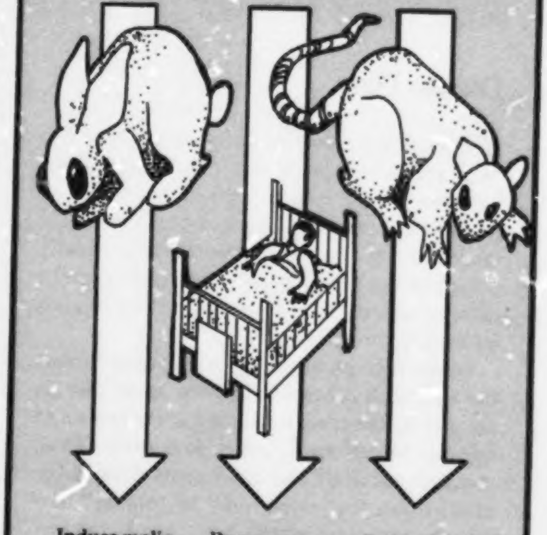
- induced malignant tumors in one or more animal species,
- induced benign tumors that are generally recognized as early stages of malignancies, or
- proven carcinogenic in epidemiological studies.

With these requirements underlying the list, those who make use of it can be assured that the compounds in question have shown substantial evidence of carcinogenicity. However, the list is relatively new and does not yet include all the chemicals shown to possess such evidence.

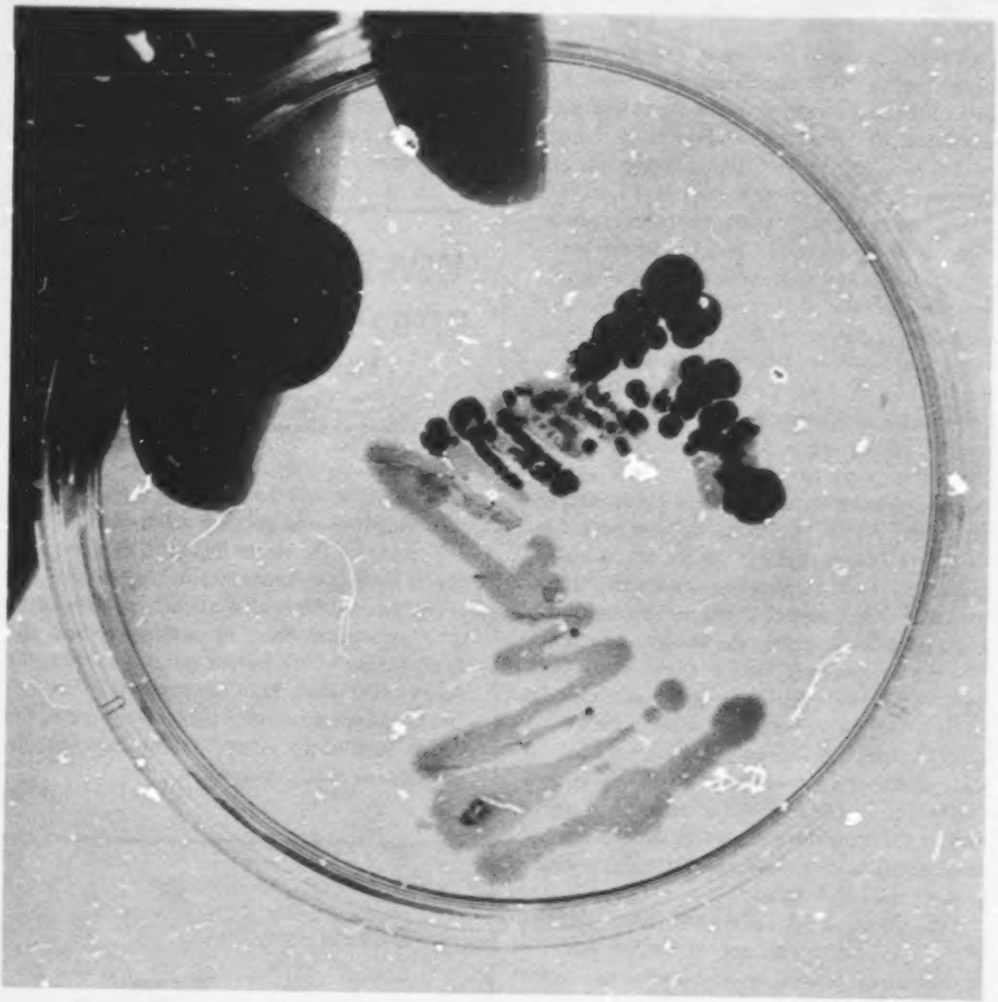
> EPA has subsequently proposed to cancel the use of 2,4,5-T

Recent uses for the list include EPA's preparation of hazardous waste disposal regulations, the potential establishment of labeling regulations for toxic substances used in commerce, and the development of laboratory safety standards for Agency personnel. The Occupational Safety and Health Administration is also making use of the list as part of its effort to limit exposure to carcinogens in the workplace.

To appear on the EPA list, compounds must first have been demonstrated to either:


Induce malignant tumors in one or more animal species.
Be proven carciogenic in epidemiological studies.
Induce benign tumors that are generally recognized as early stages of malignancies.

Cultures in petri dishes are used in EPA's risk assessment and health effects research



Dioxin Data

One of the problems facing researchers who study toxic pollutants is that the scientific literature on the subject is so voluminous that more time is spent weeding through it than in the laboratory. Worse, the literature is often poorly presented, contradictory, or even misleading. The data on dioxins is a prime illustration of such information overload.

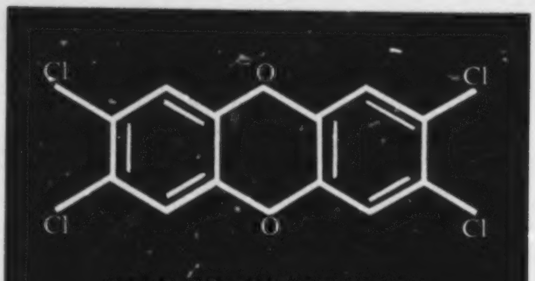
Dioxin is the generic name for a group of hazardous chemicals of varying toxicity. Some dioxins are among the most toxic substances known to science, others are far less dangerous. Thus, comparisons made and conclusions drawn from information that refers only to "dioxin" may often be confusing, and perhaps even dangerous.

In an attempt to reduce confusions and to facilitate future dioxin research, in 1980 EPA published a definitive three-part report on the dioxin group. The first part contains a state-of-the-art review of dioxin literature, culled from the world's most reputable research sources. Included is detailed information on dioxin chemistry, sources, degradation, transport, disposal, and associated health effects. Accounts of public and occupational dioxin exposures are included.

The second part examines the spectrum of analytical techniques that are currently used to identify dioxins, and details the development of one such recently developed method capable of detecting part-per-trillion levels of dioxins in industrial wastes.

The final part identifies the various routes dioxins take in their formation, and explores their potential presence in commercial products such as basic organic chemicals and pesticides. Pinpointed also are locations in various industrial process-streams in which dioxins are likely to be found.

Characterizing all three parts is the extreme care taken to differentiate among the various compounds in the dioxin family. Literature over the past 25 years had been concerned primarily with one extremely toxic member of the dioxin family—2,3,7,8-tetrachlorodibenzo-p-dioxin—



BASIC DIOXIN NUCLEUS

often described in both popular and technical writing as "TCDD" or, simply, "dioxin." The report series, on the other hand, addresses the entire group of dioxin compounds, using the term "TCDD's" only to indicate the family of 22 tetrachlorodibenzo-p-dioxin isomers; and when discussion turns to that most toxic isomer of the TCDD family it is specifically designated as 2,3,7,8-TCDD.

The accuracy of both data and the nomenclature along with the overall scope of the report—taking researchers from the initial formation of dioxins to the health effects, safe incineration, and ultimate fate in the environment—should make it extremely useful in EPA's dioxin standard-setting effort, as well as a standard reference for all researchers working in the dioxin field.

Burning Hazardous Wastes

Currently the most effective technology for the ultimate destruction and disposal of industrial organic hazardous wastes is controlled incineration at high temperatures. Widely used, it is a reasonably well understood process. However, in 1979, when EPA personnel set to the task of formulating specific operating and performance standards for hazardous waste incinerators, they found that a detailed technical data base was sorely lacking. Thus, as an interim step, the Agency adopted a regulatory approach that relied on permit writers applying "best engineering judgment" (BEJ) in evaluating permit applications for hazardous waste incineration. To support this approach, EPA gave its Office of Research and Development the task of developing a comprehensive permit writer guidance manual for hazardous waste incinerators.

This task was completed in 1980, and resulted in the publication of two separate documents. The first was the "Guidance Manual for Evaluating Permit Applications for the Operation of Incinerator Units," designed specifically for use by federal and state permit writers. The second, entitled "Engineering Handbook for Hazardous Waste Incineration," is a far more detailed technical reference book, to be used both in support of the first manual and as a guide for engineers planning or evaluating complex hazardous waste incineration facilities. The manuals provide EPA with a two-pronged tool that will further assure the safe and efficient incineration of hazardous wastes.

Special Treatment

When an industry wishes to discharge industrial effluents into the nation's waters, it must first file an application with EPA to do so and then receive a National Pollution Discharge Elimination System (NPDES) permit from EPA's Office of Water Enforcement. The application includes results of a chemical analysis of the effluent, identifying toxicants and other pollutants in the proposed discharge material; the permit then specifies the pollution discharge limits that must be met by the industry. In some cases, those limits will be developed as a result of best available technology guidelines, national water standards, or state water quality criteria. In other cases (especially for toxic discharges), there are no applicable guidelines, standards, criteria,

or regulations, and the permit writers and granters have to painstakingly search through masses of data to find information relative to the permit limitations. This is an expensive, time-consuming task with a high possibility for errors that could be very costly to the applicant.

Recognizing the problem, the Office of Research and Development helped to formulate a joint project with the Permits Division and the Effluent Guidelines Division to establish a common data base for use by permit writers of varying technical and regulatory backgrounds. The result of this project was the publication in 1980 of a 5000-page, 5-volume Treatability Manual, which is a compilation of all the readily available pertinent data on the treatment or removal of priority pollutants from the effluents of 34 separate industries.

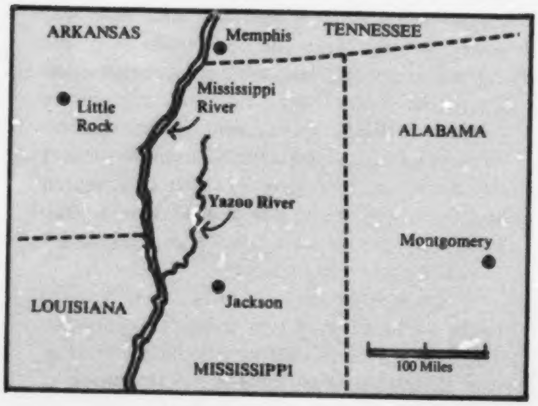
The first volume of the manual contains individual chemical data sheets for more than 200 pollutants. Included on every sheet are the compound's alternative names, and various physical, chemical, biological, and reactivity properties. Data concerning the occurrence of the pollutant among different industries are also included, as is a list of treatment technologies and their effectiveness. The second volume of the manual addresses 30 of the 34 categories of industries (work on the remaining 4 is ongoing), each of which is discussed in terms of a general industry description, a characterization of industry wastewaters, and the problems involved with the removal of wastewater pollutants. The third volume deals with the technology available for the control and removal of pollutants. Methods discussed include pretreatment, primary, secondary, and tertiary treatment, and sludge treatment and disposal. The manual's economic section is the fourth volume in which cost estimates are made for the various control systems. Volume five is a summary and reference.

The data contained in the manual will be useful to both permit writers and industry. Among the uses they may find for the manual are descriptions of the most effective treatment processes, estimates of technically-achievable reductions in the concentration of pollutants from industries, discussions of the compatibility of a proposed treatment process with others already installed, and general design criteria and cost estimates for treatment processes.

Also part of the manual is a Treatability Data Base which has recently been incorporated into EPA's Environmental Assessment Data System to allow rapid computer retrieval of needed information.

Toxaphene Risks

Toxaphene is a pesticide that has been in use for decades. One of the primary crops sprayed with it is cotton; however, such toxaphene spraying may pose a threat to the environment, particularly to freshwater fish exposed to the substance as a result of irrigation procedures and agricultural runoff. In addition, there is evidence that toxaphene is a substantial human carcinogen. EPA's Hazard Evaluation Division of the Office of Pesticide Programs requested that an assessment be made of the risks of toxaphene use. The Office of Research and Development's response was to sponsor a study, completed in 1980, to evaluate the impact of toxaphene exposure on



Runoff monitoring station

Chart recorder at the monitoring station

freshwater fish, and the levels at which the substance is lethal. The area used in the study was the Yazoo River in Mississippi for which a considerable body of data already existed. The research was based on the hypothetical application of toxaphene to the region's cotton crop over a five-year period.

To accomplish this evaluation, two mathematical models were combined. The first was a representation of pesticide runoff, transport, and fate; the second a representation of toxicological data applicable to the fish species found in the Yazoo River. Already known laboratory effects data for selected species indicated that toxaphene was acutely toxic at concentrations ranging from about 2 parts per billion for sensitive species to about 15 to 30 parts per billion for the less sensitive species.

Results of the research indicated that, under the meteorological conditions and pesticide application and management techniques tested, the exposure levels of dissolved toxaphene in the river were high enough to cause short- and/or long-term damage to a number of species including largemouth bass, bluegill sunfish, channel catfish, and fathead minnow. The study also revealed that dissolved toxaphene concentrations were very sensitive to the characteristics and amounts of sediment introduced into the river.

These research findings add strength to the scientific basis for any future actions to be taken by EPA on toxaphene.

EPA Goes Underground

The earth's subsurface is an extremely complex system, subject to extensive physical, chemical, and biological changes within short vertical and horizontal distances. Water supplies located in this remote and unseen environment are being stressed by an ever increasing population and the attendant activities, such as energy development and waste disposal. To determine the nature and extent of those stresses and to collect necessary information for actions that will alleviate groundwater problems, monitoring and sampling of groundwater quality must be performed carefully and accurately.

But monitoring is not that simple—the technology used to construct water wells is dated, and traditional sampling procedures are often inadequate to monitor groundwaters for low concentrations of chemical contaminants that may endanger the public health.

Indeed, groundwater sampling has always been more difficult and therefore more costly than surface water sampling. Groundwater quality monitoring, for example, often requires the drilling of special monitoring wells. Also, the traditional parameters used to indicate pollution of surface waters have limited value in describing groundwater quality. And, often, in the relatively inaccessible groundwater environment, the ability to simply obtain a subsurface sample uncontaminated by other media (e.g., some surface water) is, in itself, a research accomplishment of no minor significance.

In 1980, EPA published a manual of procedures for sampling groundwaters. The manual emphasizes the need to carefully select the sampling procedures appropriate to the objectives of a sampling program. Additionally, the procedures that are used need to be correct for local hydrogeologic conditions, the characteristics of the pollutants being monitored, the analytical procedures to be used, and the nature of the potential pollutant source.

Core sample being extruded in the laboratory

Water Quality Criteria

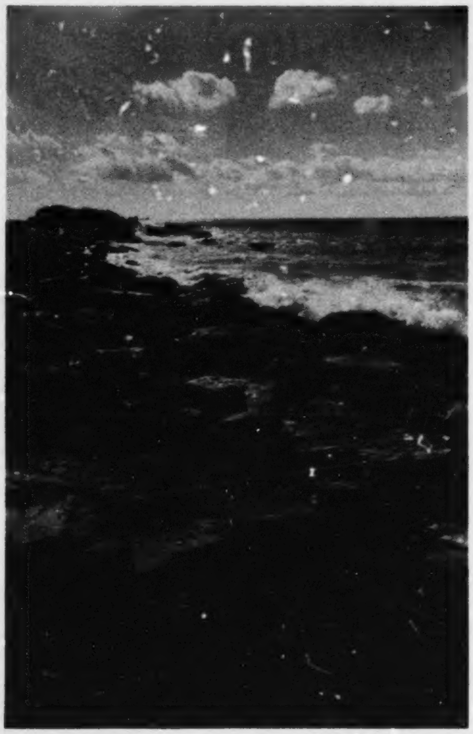
In response to a pressing EPA need for water quality criteria to support the Clean Water Act of 1977, the Office of Research and Development in 1980 prepared 64 ambient water quality criteria documents. These state-of-the-art papers contain compilations, evaluations, and correlations of currently available information concerning specific chemicals or classes of chemicals; with the information EPA can assess the potential risk of adverse effects of each pollutant on aquatic life and on human health. In each of the 65 documents is a brief history of the specific chemical, its fate in the environment, its metabolic pathways in living organisms, and any known toxic, carcinogenic, teratogenic, or mutagenic effects. The documents underwent both extensive peer and public review before final versions were published to ensure that the content was complete and up-to-date.

The documents underwent both extensive peer and public review

A criterion level— representing the amount of the chemical that may be present in water but that presents no serious hazard to aquatic or human life—was also derived for each of the 65 pollutants. These levels, prepared for use in Agency regulatory activities involved with the control of water pollution in the United States, are not to be confused with standards, however. Rather, they represent best scientific judgments of the levels of risk for a given substance based on the information available.

A second major highlight of the EPA water quality criteria effort was the 1980 publication of a document entitled "Guidelines for Deriving Water Quality Criteria for the Protection of Human Health and Aquatic Life and its Uses." The human health guidelines are for the review and interpretation of data about acute and chronic toxicity including carcinogenic, mutagenic, and teratogenic effects; methods are also described for extrapolating data from animal studies to humans. The use of epidemiological data and the appropriate methods and models for deriving criteria are also described in the document. Reviewing and interpreting data on acute and chronic toxicity in aquatic animals, toxicity to aquatic plants, and bioaccumulation in aquatic organisms comprise the guidelines for the "Aquatic Life" portion of the document.

An important aspect of the publication is that



it urges that, in the development of future criteria documents, numerical criteria *not* be developed for a pollutant unless a specified minimum array of data are available. This is seen to give criteria documents greater credibility among regulatory agencies and those polluters being regulated.

Better Data for Clean Air

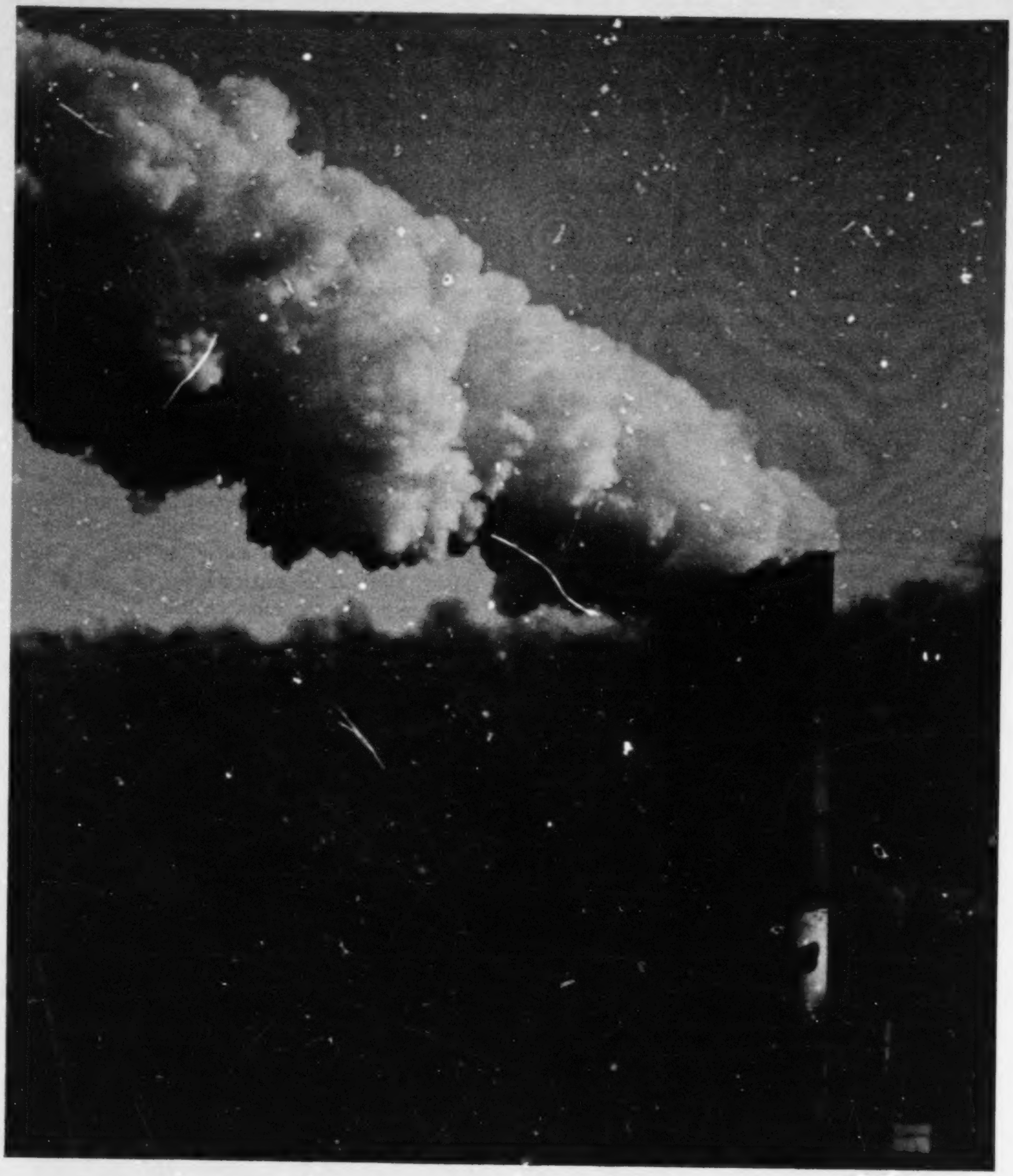
The 1977 Amendments to the Clean Air Act call for the review every five years and, if necessary, the revision of the criteria used for setting air quality standards. Seven key pollutants were singled out by the amendments for this review: lead, ozone, carbon monoxide, particulate matter, nitrogen oxides, sulfur oxides, and hydrocarbons.

Responsibility for the research to support this review falls to EPA's Office of Research and Development, with 1980 the year that the first revision cycle was to be completed. The task was by no means simple. As it was, the establishment of the criteria for setting the initial standards was a process complicated by reams of literature, often incomplete and sometimes contradictory. Thus, extensive review of criteria at that time was essential to ensure the credibility of EPA's air quality regulatory program. With the mass of data generated since these first criteria were established only 10 years ago, the process became even more complex in 1980. Each document prepared had to be subjected to a thorough review by experts within and outside EPA as well as by interested members of the general public. Such evaluations usually entailed more than one public comment period of two to three months' duration, one or more workshops with document authors and consultants, and at least one meeting with EPA's Science Advisory Board, which reviewed the document for its scientific accuracy and its adequacy for use in setting regulations. The importance of this intensive scientific review will be underscored in the near future by the expected debate in Congress over the appropriate air standards for this country.

By the close of 1980, five of the seven criteria documents had successfully gone through the various evaluation channels as scheduled, with the remaining criteria review for sulfur oxides and particulate matter expected to be completed early in 1981. Work is also already underway on the next review cycle, with the lead criteria document scheduled for completion by 1983.

The following EPA research components contributed to the research described above:
- Office of Environmental Engineering and Technology—Industrial Environmental Research Laboratory, Cincinnati
- Office of Environmental Processes and Effects Research—Environmental Research Laboratory, Athens and Robert S. Kerr Environmental Research Laboratory, Ada
- Office of Health and Environmental Assessment, Washington, D.C. and Environmental Criteria and Assessment Office, Cincinnati and Research Triangle Park

AIR POLLUTION



Understanding the causes and consequences of air pollution can help America's future air to be cleaner, clearer, and healthier.

Early in October, 1980, the city of Los Angeles underwent a Stage Two smog alert. Children in schools were denied recess. Senior citizens were warned to remain indoors. Certain industries were shut down. Automobile use, virtually the only way most citizens are able to make their way across the sprawling metropolis and its environs, was discouraged. It was as if the entire population was suddenly being prepared for an attack by a foreign enemy.

Yet air pollution is hardly foreign, created by human activity in the main, and comprised of elements that have today the ring of familiarity—hydrocarbons, sulfur oxides, particulates. While much has been accomplished in their control, the alert in Los Angeles serves to point out that in many areas, there is much left to do. Part of EPA's 1980 research uncovered air pollution information that will help reduce the amount of unhealthy air in the nation's skies.

Inhalable Particle Monitors

By the close of 1980, more than 140 monitoring sites in industrial, commercial, residential, and rural areas of the country were in operation as part of a nationwide effort to measure the levels of inhalable particulates (IPs) in the atmosphere.

Two key reasons prompted the establishment of the IP network. The first was to provide support for EPA's health effects program, which is currently studying the effects that these microscopic particles have on human health. The second reason for the IP network is to provide support to the Agency effort reviewing the adequacy of the existing air standard, which is based on total suspended particulates.

Each of the monitoring sites contains as many as five different air samplers, special instruments that collect airborne particles on filters. These filters are periodically removed by state and local air pollution personnel and sent to EPA for analysis. Each filter is weighed and selectively analyzed for a variety of constituents such as lead or sulfates. Currently more than 2400 such filters are being processed monthly, and, it is expected, by the time the network is at its peak strength of about 180 sites, this figure will grow to over 3700 filters per month.

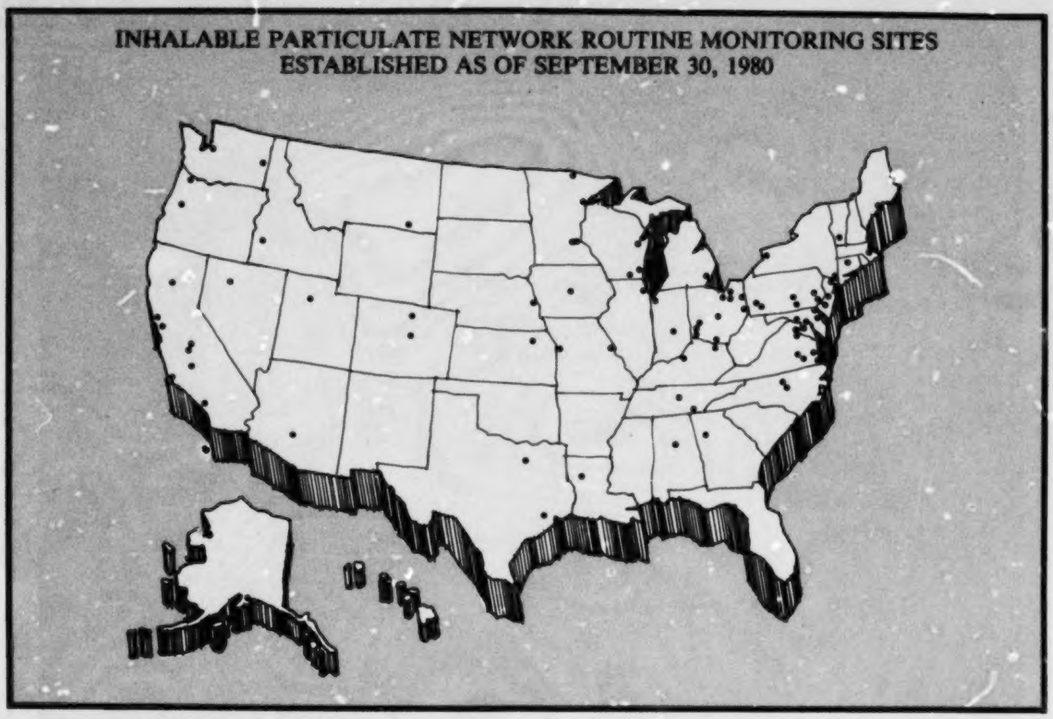
In addition to the routine network activities, some sites have been set up to gather information on specific aspects of air quality. Included are sites measuring the distribution of inhalable particulates in metropolitan areas, and sites measuring the contribution of dusts from difficult-to-control sources such as unpaved roads.

The monitoring effort will result in the establishment of an extensive IP data base, and will make possible examination of the relationship of inhalable particles to total suspended particles. Evaluation of IP health effects data will additionally help determine whether the existing air quality standard for particulate matter is appropriate to protect the public health.

Plant Monitors

Early pioneers of the science of biomonitoring were coal miners who would take a caged canary down into the mines with them as a technique for detecting dangerous levels of gaseous air pollutants. The sudden silencing of the bird's song would indicate to the miners that the air was filling with lethal gases, and soon would be fatal for them to breathe as well.

Monitoring site in the inhalable particulate network



INHALABLE PARTICULATE NETWORK ROUTINE MONITORING SITES ESTABLISHED AS OF SEPTEMBER 30, 1980

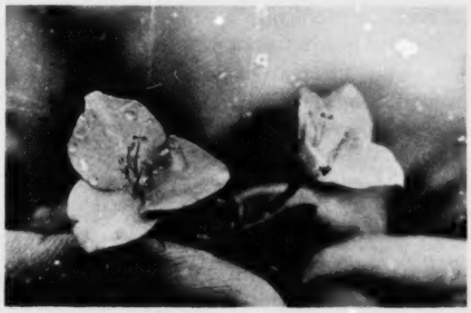
Primitive as it was, this technique was often graphically effective and has led researchers in recent years to hunt for other animals and organisms that could serve as sentinals against potentially harmful changes in the environment. EPA scientists have been particularly interested in the ability of plants to function as "biomonitors," and have in a recent research highlight, worked extensively with *Tradescantia,* to determine its potential for warning against mutagens in the air.

Tradescantia, a hybrid of the spiderwort plant that grows wild in certain parts of the country, looks like a normal houseplant with its long, grassy leaves, knobby stems, and tiny bluish-lavender flowers. Exposed to mutagens, however, its response is far from ordinary. This is particularly the case in the experimental strain of *Tradescantia,* a cross between a blue-flowering and pink flowering spiderwort, with blue the dominant color, pink the recessive. With mutagens in the air, the gene that determines the color of the plant's stamen hair cells can be altered, resulting in the appearance of the recessive or pink color. These mutations, visible under a microscope, are called "pink events," and occur 5 to 17 days following exposure.

In a recent EPA study involving *Tradescantia,* plants were taken to several large industrial cities where they were housed in a specially designed trailer that permitted free circulation of outside air. A control study was conducted in "clean" air at the Grand Canyon. Test results indicated a noticeable increase in the occurrence of pink events in the industrial cities, while the incidence of color change was quite low at the Grand Canyon site.

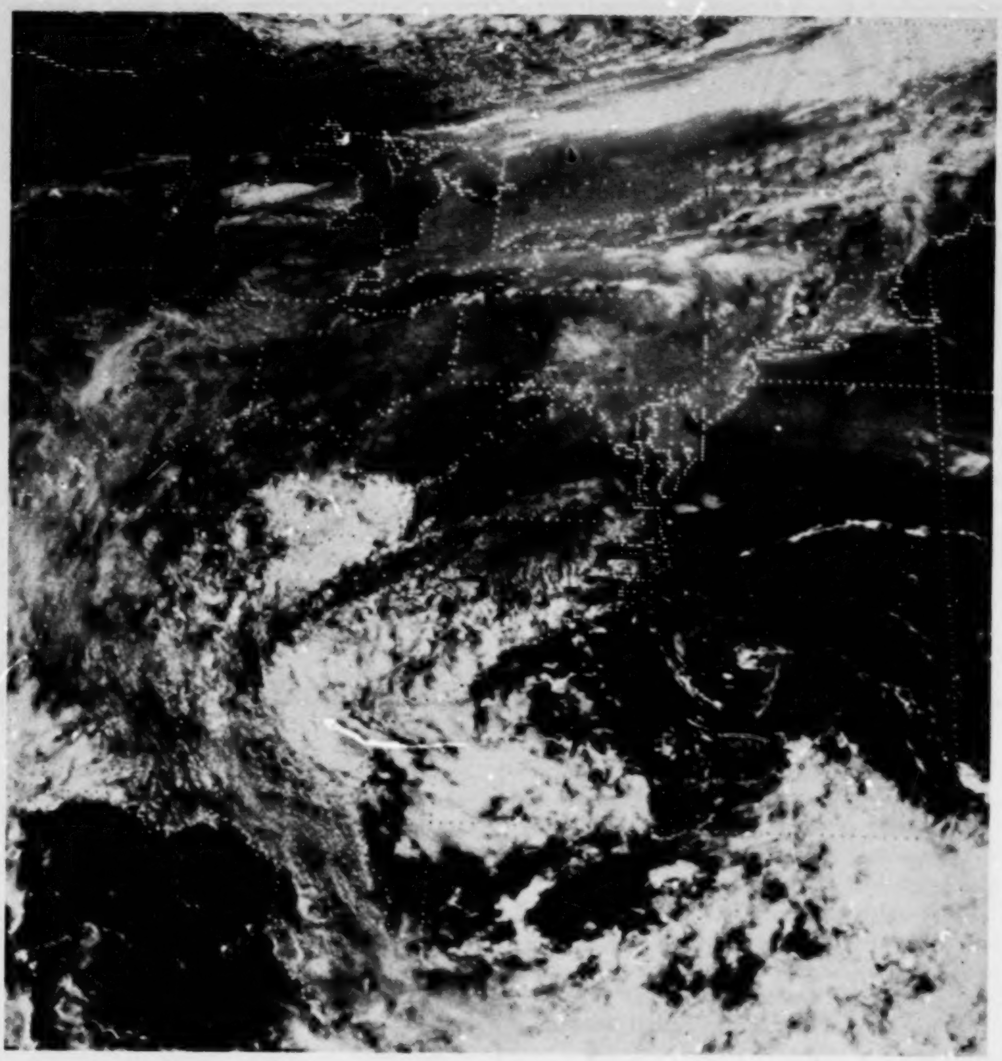
Other related research carried out by EPA involved an evaluation of methods that would automate the time-consuming microscopic examination process, and a further look at other plant species for their potential use as biomonitors. Among the plants considered were arabidopsis, barley, and corn.

While there is no guarantee that a compound that causes mutations in plants will have the same effect on humans, it is altogether probable that an agent capable of turning blue flowers to pink ones might have *some* harmful effect on people. *Tradescantia* will, in any event, not stand alone as an assay device, but will eventually be a part of a battery of mutagen-sensitive indicators that will in concert be able to detect many of the chemicals that pose a threat to human health.



Tradescantia

Hazy air stretches to the Atlantic Ocean



Hazy Blob Movie

1980 saw the final editing and release of an EPA-funded, animated sound/color film entitled "Satellite Observations of Persistent Elevated Pollution Episodes." The film and a sound track provide a powerful visual aid illustrating the long-range atmospheric transport of pollutants and their subsequent contribution to the acid rain problem.

The film, making use of EPA study data, shows how plumes from power plants and urban areas are transformed, merging with other plumes into large-scale hazy blobs that cross state, regional, and national boundaries. Also shown are animated sequences depicting the development and movement of extended areas of surface haze, which degrades visibility and the general quality of surface air. Using satellite observations, this haze is demonstrated to extend from the eastern and midwestern U.S., where it is formed, eastward and far across the Atlantic.

Also demonstrated is the close association that exists between this haze, reduced surface visibility, and elevated levels of airborne sulfates. These sulfates, along with other pollutants usually accompanying the haze—including those thought to be responsible for acid rain—are then shown feeding into developing thunderstorms. The film vividly illustrates how a simple industrial plume might actually result in the acid rain of a nation hundreds or even thousands of miles away.

During 1980, the film was shown at the EPA conference on acid rain, and to a number of federal and state officials as well as to members of the Canadian government. Parts of the film may be excerpted for future inclusion into Public Broadcasting's NOVA series.

Lost Vistas

Unlike many forms of environmental degradation where the damage done is subtle and invisible, with degraded visibility, what you see is what you get. To quantify information about visibility impairment, however, is by no means a straightforward, simple task. Rather, it involves a variety of state-of-the-art monitoring techniques, many of which appear in EPA's "Interim Guidance for Visibility Monitoring," prepared in 1980 for publication in the Federal Register, and for reference in future visibility regulations.

The importance of such guidance to the promulgation of these regulations cannot be overestimated. Required by the regulations is an assessment of visibility impairment, which requires monitoring which, in turn, means the gathering of valid and meaningful data. To accomplish the data gathering, standard techniques and procedures and a quality assurance program must evolve, and it is here that proper guidance can make the difference between credible, enforceable laws, and those challenged by the polluters who are obliged to respect and conform to them. Thus, the guidance must be comprehensive and scientifically sound. The EPA guidance document was prepared by the Office of Research and Development with this end in mind. Among the recommended monitoring techniques included are:

- measurement of the apparent contrast of a scene (i.e., how vivid the differences are between light and dark colors) with telephotometers;
- photographic documentation of scenes during clear and hazy conditions;
- measurements of fine particulates (less than 2.5 um) which are known to contribute to degraded visibility.

Work continues to assure that guidance is kept current, reflecting all up-to-date developments in the measurement of visibility impairment.

MAP3S/RAINE

In 1976, a long-term study was initiated to define the relationships between the emission of air pollutants, their deposition, and the chemical make-up of precipitation. Referred to as the MAP3S/RAINE program (which stands for Multistate Atmospheric Power Production Pollution Study/Regional Acidity of Industrial Emissions), the study focused primarily on those pollutants emitted by fossil-fueled electrical generating facilities. The ultimate goal of the effort was to determine the pollution sources responsible for chemical deposition across the United States so that effective control strategies could be developed by EPA.

Taking visibility measurements in Nevada

Specifically, results from the study were needed to improve methods by which air pollution loads are quantified and pollutant transport estimates are computed. From these results and others, we will derive a greater understanding of how pollutants are transformed and the rates at which they are converted into dry or wet acid deposits.

Following nearly four years of extensive monitoring, sampling, and analysis, at the eight stations that made up the MAP3S/RAINE network, a number of general conclusions have been reached:

- Different geographical locations experience substantial differences in precipitation chemistry. For instance, stations in the New York/Pennsylvania area experience greater rain acidity than do those stations to the south. These differences are reflected in absolute concentrations of pollutants, in their relative mix, and in correlation between different pollutant species.
- For the westernmost stations in the network, the soil dust plays an important role in dictating the chemical make-up of precipitation.
- For the easternmost stations, hydrogen ion concentrations correlate strongly with sulfate and nitrate ions, the upshot of this being that acidity can be estimated with reasonable accuracy from these ions alone. This correlation tends to weaken on the western side of the network.
- All stations report the distinct annual cycling of some species such as sulfate and ammonium, thus leading to maximum concentrations of most species being delivered during the summer months.
- In general, there were negligible trends detectable in ion concentrations over the study period.

The data gathered by this study will help to further substantiate the causes of acid rain—and other pollution episodes—thus eventual acid rain control strategies or regulations may be developed, in large measure, from the MAP3S/RAINE project.

Plume Tracking

In the summer of 1980, EPA managed a $2 million air pollution study that was one of the most comprehensive ever undertaken. The project, called the PEPE Study (Persistent Elevated Pollution Episodes), pinpointed plumes of air pollution as they were formed around cities, industrial areas, and power plants, then tracked them through the Northeast and into Canada.

Participating in the study, which spanned much of July and August, were seven federal agencies, state and university representatives, and the Canadian government. Much of the effort involved the sophisticated in-air monitoring and sampling of pollutants and other atmospheric data. Aircraft were deployed to measure aerosols, ozone, and a variety of other pollutants at altitudes up to 17,000 feet. Other aircraft monitored turbulence and its effect on pollutant dispersion. In addition, an EPA plane carrying LIDAR—a laser instrument for probing the atmosphere—was used to measure the vertical distribution of aerosols. The sampling flights covered the region from New York City to as far south as Arkansas. Large balloons released into parcels of pollutant-laden air in the region were tracked as they were carried by prevailing winds in a generally northeasterly direction.

Elsewhere, samples were being analyzed, dry deposition and acid rain were being studied, planes were being maintained, and sampling equipment was being calibrated and repaired as necessary. Direct voice contact among all participants was made possible by a communications plane.

The PEPE Study was also designed to tie in with the Northeast Regional Oxidant Study (NEROS) that began in 1979 and is aimed at measuring oxidant air pollutants, and providing a data base to test EPA's oxidant air pollution model. This combination of study data will eventually result in a comprehensive overall data base that includes ozone, the major oxidant, as well as the aerosols, sulfates, and nitrates that are the major components of most industrial plumes.

More important than the data base, however, is the large gain in knowledge about atmospheric processes. We now have a better understanding of how various compounds and aerosols are formed in the atmosphere and how they are subject to long-range transport.

The following EPA research components contributed to the research described above:

- Office of Health Research—Health Effects Research Laboratory, Research Triangle Park
- Office of Environmental Processes and Effects Research—Environmental Sciences Research Laboratory, Research Triangle Park
- Office of Monitoring and Technical Support—Environmental Monitoring Systems Laboratories, Research Triangle Park and Las Vegas

WASTEWATER

EPA works with industry and agriculture to find solutions to the problems posed by billions of gallons of wastewater.

Wastewater from the textile mill being sampled

Water, water everywhere . . . and much of it is wastewater; water that has been used at least once, and must be carefully scrutinized before it is allowed to re-enter the environment from which it was withdrawn. What impact, for example, has a specific industrial process had on water's future drinkability? What impact will wastewater have if injected underground, released into a stream, a river? What effect has its use for agricultural irrigation had on its chemistry? Did it come into contact with pesticides, insecticides, fungicides?

Today, literally thousands of substances are found in wastewaters, some with the potential for harm in concentrations as slight as a few parts per billion. EPA's wastewater research program seeks to develop methods to characterize these substances, and to develop wastewater controls so that the wastewaters that do enter the environment threaten neither human health nor the well-being of important ecosystems.

ORD and Industry Cooperation

In 1974, the American Textile Manufacturers Institute (ATMI) petitioned a U.S. Circuit Court of Appeals to review proposed EPA wastewater regulations. The regulations in question were those that specified the use of best available technology economically achievable by 1983 for the limitation of specific pollutant discharges into textile industry wastewaters; it was industry's contention that such technologies and their economics had yet to be demonstrated. In contrast to the usual claims and counter-claims of court cases, the petition resulted in a cooperative industry/EPA research project to evaluate the feasibility of the Agency's control requirements.

A 30-month engineering and economic study was begun in 1976 to resolve the issues. EPA was to supply and test the wastewater control technologies; industry was to allow the EPA researchers access to the textile plants and wastewater streams. Involved was the design, construction, and field operation of two mobile wastewater treatment units which were to be trailered to a total of nineteen textile plants representing six of the seven industry subcategories established by EPA. Contained in each mobile unit were demonstration-scale systems of four different technologies—multi-media filtration, coagulation/clarification, carbon adsorption, and ozonation. The units were designed to make use of the technologies individually or in combination. In addition, laboratory tests were to evaluate the potential uses of air flotation technology and powdered activated carbon added to biological treatment systems. Once underway, the study was expanded to include an evaluation of how effectively the treatment technologies under investigation reduced toxicity and concentrations of those 129 specific compounds referred to as "priority pollutants." A single overall goal remained, however: determining the best available technology economically achievable (BATEA) for removing pollutants from textile wastewater.

Treatment technologies were tested at textile mill wastewater ponds

1980 saw the culmination of this research and the publication of study findings. Some key conclusions:

—ten of the nineteen plants tested could meet BATEA limits by making use of one or more of the advanced wastewater treatment process technologies tested;

—eight of the nineteen plants tested failed to achieve 1977-mandated best practical control technology levels for secondary treatment facilities;

—the coagulation/clarification process performed well in four of six industry subcategories, effectively treating most of the pollutants being measured;

—the multi-media filtration process performed well in most cases for total suspended solids removal, particularly when used in tandem with coagulation/clarification;

—the granular activated carbon adsorption process performed well when compared to other advanced wastewater treatment processes for color and organics removal in five of six industry subcategories;

—the ozonation process achieved color removal below BATEA limits at selected sites but chemical oxygen demand levels exceeded 1983 requirements.

Study results will be used by EPA's Effluent Guidelines Division in their development of 1983 textile industry wastewater guidelines. Because of this cooperative EPA-industry research effort, the resultant regulatory guidelines will be based upon solid scientific evidence gained under actual operating conditions. This should help to assure that the controls adopted by this industry are not only effective, but cost-effective as well.

Combined Industrial/ Municipal Treatment

For the last several years, EPA has been investigating whether some untreated industry wastewaters are amenable to treatment in combination with municipal wastewater in publicly owned treatment works.

In a joint 1980 investigation, EPA's Effluent Guidelines Division, and its Office of Research and Development, along with industry, evaluated the impact of one semiconductor industry's wastewater on a biological wastewater treatment process. The study set out to determine whether any environmental hazard was being posed by the wastewater and whether wastewaters would require any pretreatment before entering the municipal wastewater treatment system. The study also was to evaluate any air emissions or solid wastes attributable to the industry and generated during the treatment process. For the purposes of the evaluation, a pilot-scale biological treatment system was employed.

A pilot-scale unit is used to determine compatibility of industrial wastes with municipal treatment

Specifically, the study was to answer a number of key questions: Were, for example, sudden surges of wastewater compounds overtaxing the municipal wastewater treatment system? And were some of these compounds actually going through treatment unchanged? And also, did these compounds tend to concentrate in high levels on the activated sludge wastes common to many treatment processes, thereby transforming a wastewater problem to a solid waste problem?

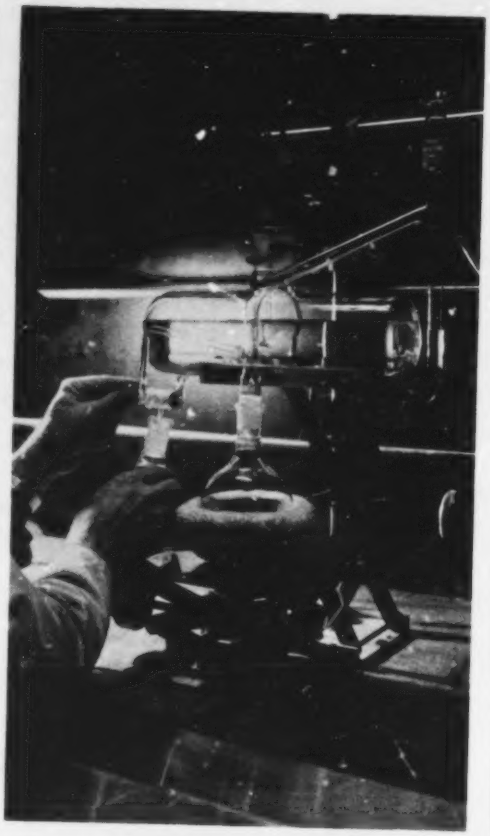
Results of the study indicated that, for the particular semiconductor industry being evaluated, untreated industry wastewaters had no overall adverse effects on a pilot-scale biological treatment system. Thus, our research showed that at least some parts of this major industry might be able to avoid the expense of installing their own wastewater treatment systems and could discharge untreated wastes into municipal systems with no serious degradation of these systems.

The information developed by this study will be provided to the EPA Effluent Guidelines Division to support the Agency's determination as to whether pretreatment is necessary in this case.

Organics Analysis

Analytical methods and instruments have, over the last decade, been significantly improved and refined to the point where today it is indeed possible to find the proverbial needle in the haystack; or locate a specific compound present in minuscule quantities in a drop of wastewater. Identifying one unit of a chemical in a trillion units of a water sample is a reality. Problems arise, however, when researchers or pollution monitoring personnel are not looking for a specific compound or group of compounds but are looking instead for a wide variety of different compounds with different properties and varying physical characteristics. A protocol that is tailored to look for one compound cannot be used when many compounds in a single sample must be identified and measured.

In 1978 EPA researchers tackled this extremely complex problem and in 1980 came up with a first generation Master Analytical Scheme for identifying and quantifying virtually any of the



hundreds of volatile organic compounds that might be found in almost any drinking water, surface water, or industrial and municipal wastewater sample. The scheme allows maximum separation and recovery of a selected class of compounds and includes analysis procedures for groups of water-soluble organic compounds for which comprehensive methods have not been previously available. No longer, in any event, must researchers be limited to looking for specific compounds, when their goal is to identify many. The primary tool used in the Master Analytical Scheme is capillary column gas chromatography-mass spectrometry. Old and new analytical techniques were brought to bear in the scheme's development, and the quantitative factors characterizing several hundred compounds were collected in a computerized data base. Using the analysis procedure and the extensive data base of the scheme, analytical chemists in government, industry, and academia will be able to identify and quantify any volatile compound (i.e., one that is readily vaporized) of the 45,000 commercial organic chemicals that may be released into the environment. A report describing the development and refinement of the scheme and its implications for environmental samples will be available in 1981.

Predicting Agricultural Runoff

The possibility that national water quality goals may not be met in the future has been suggested by a number of studies conducted over the past several years. The likely culprit? Pollutants released by nonpoint sources—feedlots, harvested timber-slopes, and agricultural fields. A joint research effort by EPA, the U.S. Department of Agriculture and the U.S. Geologic Survey was launched in 1979 to develop a predictive analysis of pollutant discharges from the agricultural nonpoint sources, one of the largest contributors to the nonpoint loadings.

The purpose of this study was threefold: first, to analyze the national water quality impacts of sediment and sediment-attached pollutants discharged from non-irrigated cropland; second, to identify where sediment controls on cropland would result in the achievement of downstream water quality targets; and third, to estimate the costs of these controls. It was also thought that study results would help in implementing best management practices (BMPs) for priority problem cases as required by 1977 clean water legislation.

The analysis relied on the use of a water quality model to estimate the pollutants discharged from all U.S. industrial, agricultural, household, and municipal polluting activities, broken down on a county-by-county basis. The model linked these activities to a detailed network of 204 rivers, 175 lakes and reservoirs, and 37 bays. Discharge estimates were made for biochemical oxygen demand, total suspended solids, total dissolved solids, total phosphorous, heavy metals, and total nitrogen. Once the various pollutant figures were plugged into the elaborate model network, it was then possible to predict readings of pollutant concentrations at more than 1300 downstream points. Information was then merged with U.S. Geologic Survey hydrologic data and ambient water quality concentrations were estimated. These estimates allowed a determination of where water quality problems may exist and where they may be alleviated once cropland sediment controls or other measures are adopted.

In the study, the model was run to simulate an annual pollutant discharge load under: current

Runoff from a feedlot

conditions, fully implemented best practicable technology (BPT) and secondary municipal treatment, and cropland sediment control policies for the entire nation.

Key research findings included:

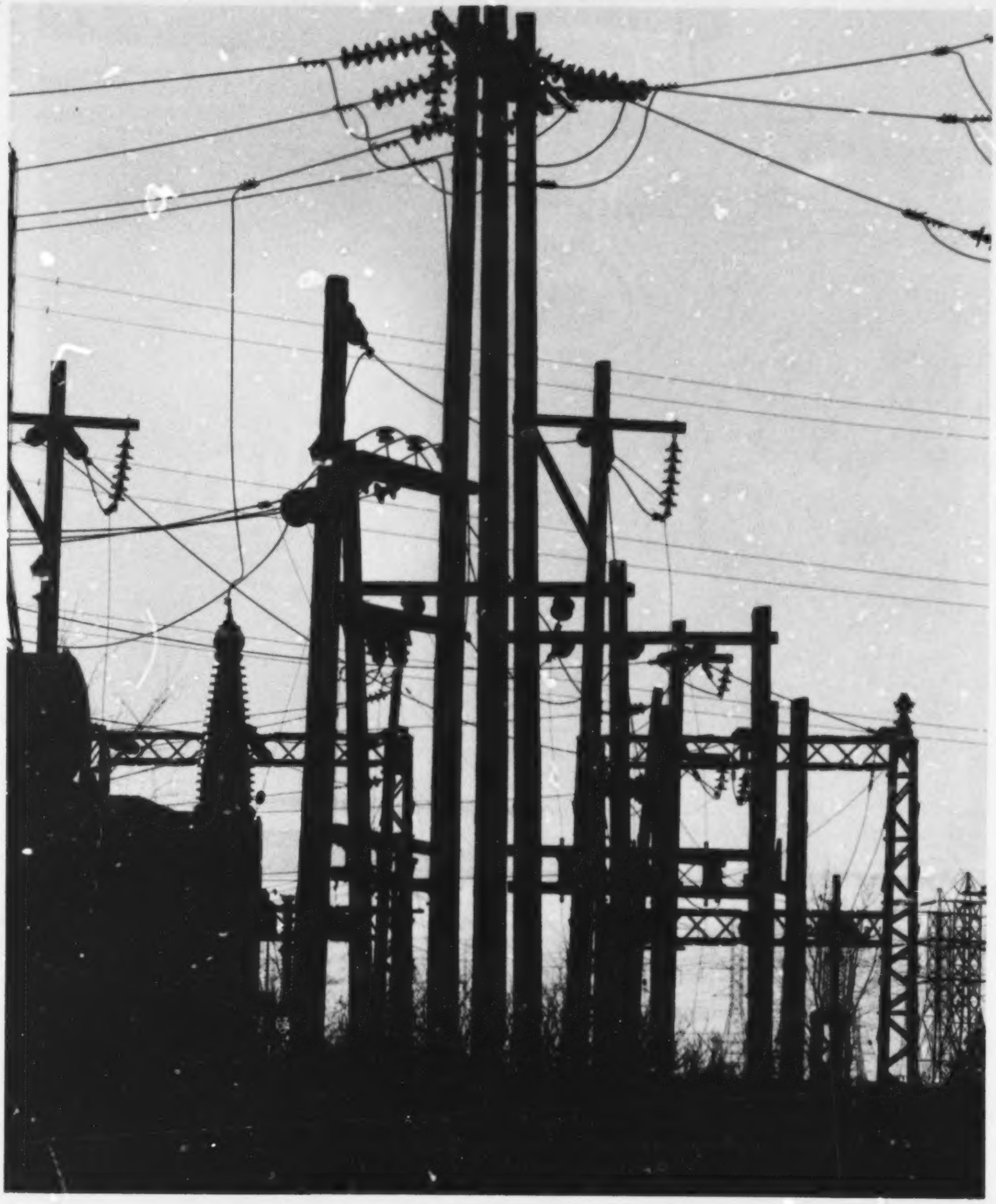
- as compared to earlier studies, the relative contribution of pollutants from croplands remains constant; however, absolute discharge levels are lower than previously estimated;
- the most serious problem relative to the contribution of cropland discharges to water quality is in the Midwest;
- even following full implementation of BPT, secondary treatment, and cropland controls, a substantial number of the locations in the network would be in violation of the nitrogen and phosphorous standards, while a lesser number would be in violation of a 5-day biochemical oxygen demand standard.

Model results, reflecting a previously unavailable scope, provide the most systematic basis for predicting pollutant concentrations to date at the national level. By targeting the implementation of agricultural BMPs, this information may lead to considerable savings in the cost of sediment controls, both to the farmers and to the society the controls serve. Work with the model continues, with the study targeted for completion by 1981.

The following EPA research components contributed to the research described above:

- ■ Office of Environmental Engineering and Technology—Industrial Environmental Research Laboratory, Research Triangle Park
- ■ Office of Environmental Processes and Effects Research—Robert S. Kerr Environmental Research Laboratory, Ada and Environmental Research Laboratory, Athens

ENERGY



A national energy future that is safe, efficient, and at reasonable cost lies at the heart of EPA's aggressive energy research.

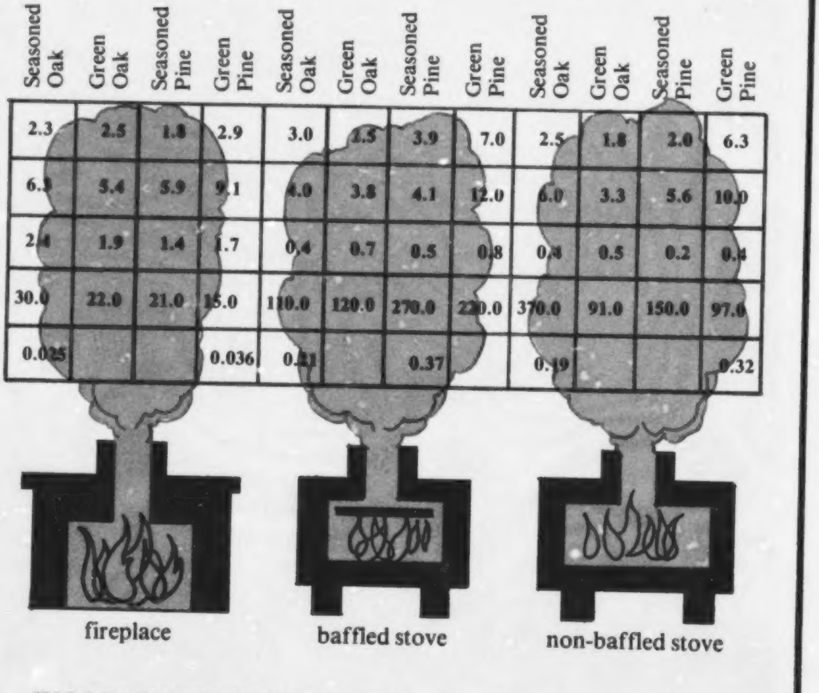
Since 1974, EPA has been managing the federal Interagency Energy/Environment Research and Development Program. Each year EPA and the other members of the 17-agency program have produced information and developed and tested technology to support national policies that make ample domestic energy available, affordable, and environmentally safe. 1980 was no exception. This year's highlights, which represent only a fraction of the many research projects under the aegis of the program, range from a study of the effects of ambient air on diesel exhausts to tests of methods to automate flue gas scrubbers.

Wood for Home Heating

By the year 2000, the U.S. Department of Energy hopes to see a threefold increase in the use of wood for home heating. Such residential combustion today already provides the heat equivalent of 140,000 barrels of oil daily, with over a million homes using wood as a primary heat source. By 1985, it is estimated that over 10 million homes will be using at least some wood fuel.

The questions facing EPA are: What effect will all this wood burning have on ambient air quality? On air pollution? On human health? To find answers to these questions, EPA researchers are characterizing the types, amounts, and air quality impacts of emissions from wood combustion. Additionally, attempts are being made to find better ways to burn wood to reduce emissions. Projects include sampling and analyzing wood stove emissions and studying air quality in communities that burn predominantly wood for space heating. One project, completed in 1980, compared wood combustion emissions with other stationary source emissions, while also determining the factors that can alter the nature of these emissions.

Homes were surveyed to determine how much wood was being burned, then estimates were made of the total number of pollutant emissions—particulates, sulfur oxides, nitrogen oxides, carbon monoxide, hydrocarbons, and polycyclic organic matter (POM)—that originated from home wood combustion. Compared with other emissions sources, it was found that residential wood combustion can be a major source of ambient POM. It has not yet been determined, however, whether these organics can be reasonably expected to endanger public health, although certain POM compounds have been shown to cause cancer in laboratory animals. The study also



	Seasoned Oak	Green Oak	Seasoned Pine	Green Pine	Seasoned Oak	Green Oak	Seasoned Pine	Green Pine	Seasoned Oak	Green Oak	Seasoned Pine	Green Pine
Particulate matter	2.3	2.5	1.8	2.9	3.0	1.5	3.9	7.0	2.5	1.8	2.0	6.3
Condensable organics	6.3	5.4	5.9	9.1	4.0	3.8	4.1	12.0	6.0	3.3	5.6	10.0
NOx	2.4	1.9	1.4	1.7	0.4	0.7	0.5	0.8	0.4	0.5	0.2	0.4
CO	30.0	22.0	21.0	15.0	110.0	120.0	270.0	220.0	370.0	91.0	150.0	97.0
POM	0.025			0.036	0.21		0.37		0.19			0.32

Emission Rates shown are in grams of pollutant emitted per kilogram of wood (as received basis) burned. Blanks indicate no data were obtained.

WOOD COMBUSTION TEST RESULTS

revealed that residential wood burning may be responsible for 1% of the nation's particulates, 1.5% of its hydrocarbons, and 3.8% of its carbon monoxide emissions, based on 1976 ambient air quality figures.

The emissions factors part of the study identified mistakes in the construction and installation of wood-burning devices, and errors in the manner in which the wood was burned. Excess air levels and the arrangement of the wood in the firebox were found to be major factors that determine variations in wood combustion emissions. However, combustion equipment and wood type were also shown to influence such variations. CO, NO_X, and POM emissions were all affected by combustion equipment, for example, with greater amounts of CO and POM emanating from wood stoves and greater NO_X emissions from fireplaces.

These study results and the preliminary results of other EPA research point to the inability of wood burning devices to achieve complete combustion of wood fuel as the major reason for wood combustion's contribution to air pollution. With further research, however, improvements in wood burning technology are expected to alleviate this problem.

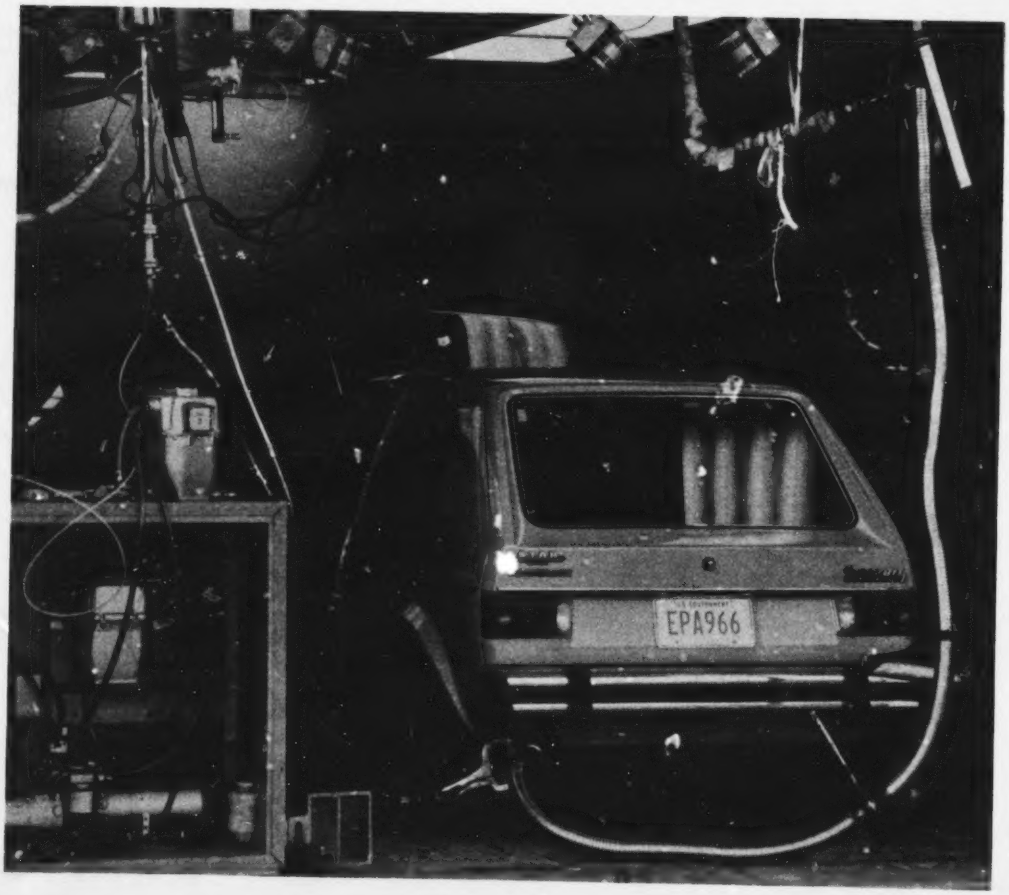
Mutagenic Diesel Exhausts

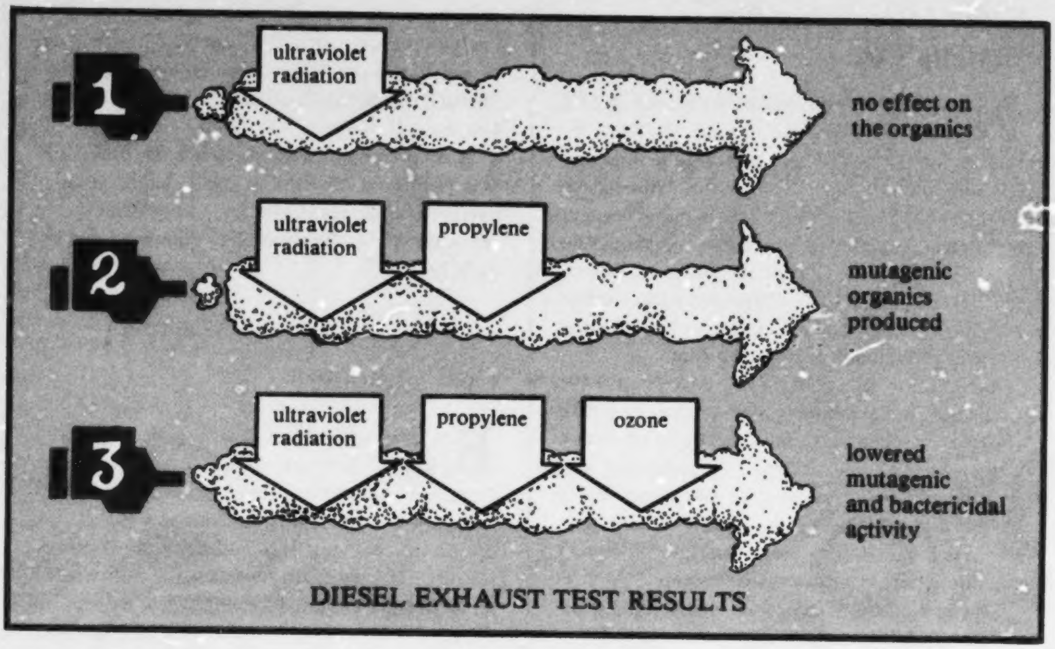
By the close of the 1970s, a number of studies had already demonstrated that organic substances found on diesel exhaust particles were mutagenic. What EPA scientists were then curious to know was what effects the ambient air would have on these mutagens—what, in other words, was happening in the wake of the diesel automobiles dotting the nation's highways in increasing numbers.

In a 1980 study, diesel exhausts were injected into smog chambers under a variety of conditions and the resulting particles were collected. Organics on the particles were then chemically removed and subjected to an Ames bioassay. Among the key findings of the study was that ultraviolet radiation in the absence of other mitigating factors had no effect on the organics. However, when a simple hydrocarbon, propylene, was combined with the NO, NO_2, and SO_2 combustion products, and the mixture then irradiated with ultraviolet light, ozone and a complex array of organics were produced, some of which were mutagenic.

Also established was that the presence of ozone clearly alters the type and level of mutagenic compounds detected by the Ames test, both those

Diesel exhausts are collected and analyzed to determine their physical and chemical make-up




1
ultraviolet radiation
no effect on the organics
2
ultraviolet radiation
propylene
mutagenic organics produced
3
ultraviolet radiation
propylene
ozone
lowered mutagenic and bactericidal activity

DIESEL EXHAUST TEST RESULTS

created by the exhaust itself and those created when propylene and combustion products are exposed to ultraviolet light. The effect of the ozone is to *lower* overall mutagenic activity, to change the nature of this activity, and to reduce bactericidal activity.

This research is significant because if diesel exhausts are to be altered to reduce mutagenic and carcinogenic threats to people, a clear understanding of the manner in which the mutagens are formed is essential *before* the alterations are put into effect. The complexity of the problem, however, as indicated by the EPA research, means that more must be learned before optimal exhaust alterations become part of future diesel designs. To gain the additional knowledge, EPA has scheduled future research to further explore the factors that influence the mutagens that are released into the air.

Allergies to Hydrocarbons

Grasses, trees, plant pollens, food, insect venoms, industrial chemicals, animal dander: these are all potential allergens, specific agents that can result in an allergic reaction within an individual. These reactions may sometimes be mild, sometimes serious, and sometimes even life-threatening. However, until the source of the reaction is established, rarely can symptoms be alleviated, or a cure for the pandemic disease known as "allergy" be found. The problem is further complicated by the fact that thousands of allergens exist and, in many cases, the specific agent causing the allergy symptom is simply unknown. However, once a person is diagnosed as being allergic to a previously unidentified allergen, further study of a special immune globulin, called I_gE, in the person's blood serum can lead to subsequent identification of the allergen in others.

For this reason, EPA researchers expressed interest in the 1979 case of a diesel mechanic who received a medical discharge from the U.S. Army after it was demonstrated that he was severely allergic to both diesel exhaust and diesel fuel. Documented by the presence of elevated levels of I_gE in his blood serum found by Walter Reed Army Hospital researchers, the individual was the first verified case of such an allergic reaction.

Late in 1979, in cooperation with Walter Reed personnel, EPA was put into contact with the individual who subsequently agreed to submit to further testing, which included the drawing of more blood serum. Using the serum, EPA worked in 1980 to develop a radiotracer method to identify the specific allergenic reactive immunoglobuline fractions in the man's blood. Also determined was the avidity of the I_gE toward diesel exhaust particles. This research was undertaken as part of our program to detect hydrocarbons in drinking water.

Once in possession of a standardized and validated "exhaust particulate specific" I_gE assay, EPA will, in the near future, be ready to analyze small blood samples of individuals with allergies of unknown causes. At the close of the research year, this work was well underway.

Better Information for Burning Coal

Nowadays the burning of coal has become, of necessity, a precise science. It must be known, for example, what kinds of minerals a coal contains and in what concentrations to determine its suitability for specific boilers; mineral content also determines, in part, end-process gaseous and solid pollutants. And if the coal is to be cleaned by mechanical means, it is important to know not only how much sulfur it contains, but how the sulfur is distributed through the coal.

By making use of a newly developed EPA procedure, boiler operators can now perform coal analyses quickly, inexpensively, and with a high degree of accuracy. It will help industrial and commercial boiler owners to burn coal more cleanly and effectively and, possibly, as coal types are better matched to boiler configurations and operating parameters, less expensively.

The procedure, Microprobe Analysis of Sulfur in Coal (MASC), makes use of a scanning electron microprobe to measure major mineral concentrations in the coal, including sulfur, iron, silica, aluminum, calcium, and potassium. The procedure also makes it possible to gauge the spatial distribution of these minerals, by projecting an image of the coal's surface on a video screen where the configuration of the elements can be clearly observed.

The procedure is fully automated to provide particle count, size, texture, and concentration data. A major improvement over previous coal analysis procedures, which depended on chemical or bulk analyses, MASC can collect all particle characterization data on a 200 mg coal sample in less than 15 minutes.

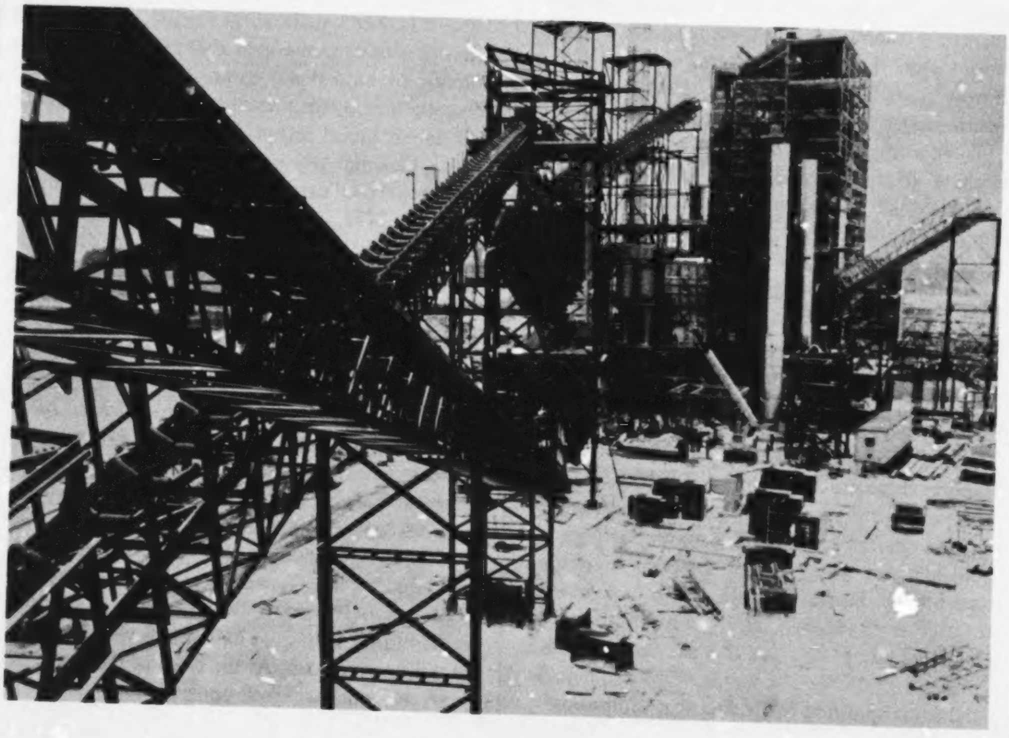
A report of the basic electroprobe procedure was published by EPA in 1980. The process is currently undergoing testing and refinement but is expected to be available commercially by July 1981.

Coal Cleaning

Before coal is burned it can be physically cleaned of much of its sulfur and other potential pollutants. Such coal cleaning is receiving considerable attention at EPA as one option for reducing SO_x emissions from energy sources. Of particular interest is the potential of physical coal cleaning technology to cut down on the production of SO_2, much of which finds its way back to the earth in the form of acid deposition.

In 1980, coal cleaning research highlights included the publication of a coal data base report and the continuation of a study on emission reduction potentials.

The data base report described both coal quality (such as its sulfur and ash content) and the cleanability of coal reserves for the largest coal-producing states. The emission reduction



The Homer City, Pennsylvania plant cleans its own coal on the premises potential study will, when complete, specify the level of coal cleaning required to meet various SO_2 emission reduction scenarios. This will be accomplished on a state-by-state as well as on a national level. Costs of meeting reduction scenarios will also be determined.

As the information produced by such research studies helps maximize the use of physical coal cleaning, EPA sees the potential for cleaner air in the future, even in the face of the increased burning of coal.

Coal Wastes as Fishing Reefs

On September 12, 1980, EPA personnel joined New York Governor Hugh Carey, along with reporters and representatives from industry and federal and state agencies, for a first-of-a-kind event. They gathered aboard ship to witness the culmination of a cooperative EPA-funded project that explored viable alternatives to the land disposal of wastes generated in the burning of coal. What they witnessed was the dropping of a total of 18,000 blocks of coal combustion wastes, a total of over 500 tons, into the Atlantic Ocean some 40 miles east-southeast of Manhattan. Not to be confused with ocean dumping, this procedure was actually designed to serve a useful purpose—creating reefs to enhance marine life and perhaps improve the catch of local fisheries.

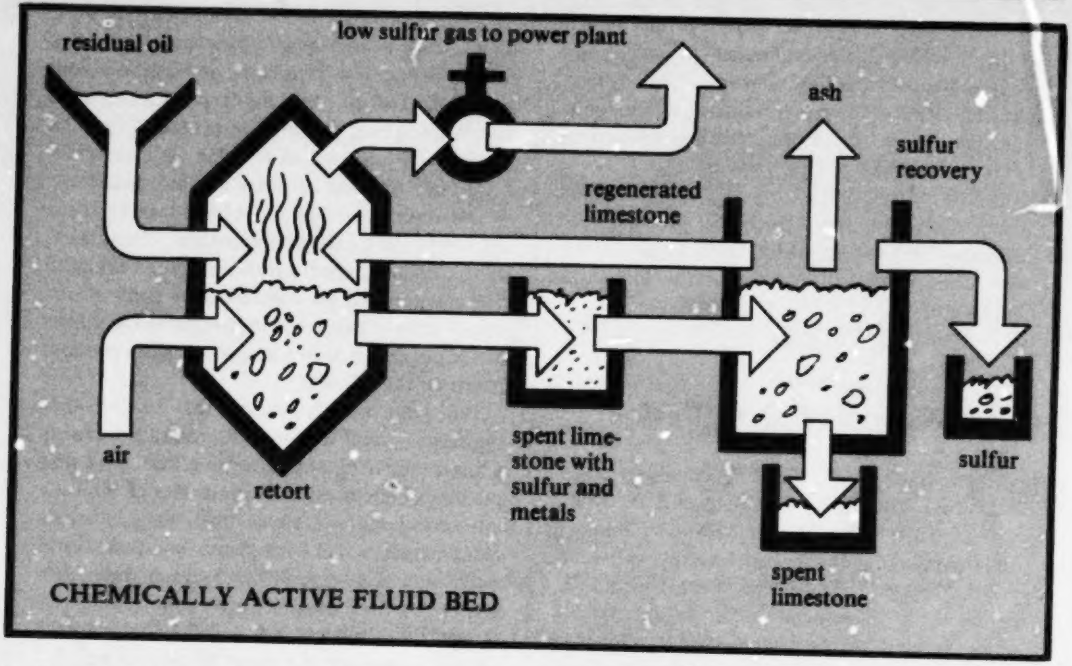
The idea of using flyash and scrubber wastes to create fishing reefs had been germinating for some time among researchers. It grew out of extensive 1977 investigations into coal combustion wastes and their reaction to long-term immersion in ocean water and the environmental effects that they might have on marine life. A field study followed. In 18 feet of water in a bay near Long Island, several one-cubic-foot blocks were stacked into separate mini-reef formations. These reefs were then examined periodically for biological colonization and photographed by scuba divers over a span of two years to determine the effects of sea immersion on block structure when exposed to strong tidal flows.

When the research indicated that fish and other organisms could live on and around the blocks without suffering any harmful effects, and that the blocks remained solid in the face of both sea immersion and tidal flows, plans for a full-scale demonstration reef took shape, one that would make use of 60-pound blocks each measuring 8 x 8 x 16 inches or slightly more than 7 cubic feet. It was these blocks—all 18,000 of them—that were dropped into the ocean on September 12.

Disposed of on land, these 500 tons of waste would have covered about half an acre of land to a depth of about 8 inches. Yet this amount of waste can be generated in only a six-hour run of a good-sized coal plant. As a consequence, when oil-fired plants convert to coal, the demand for land for coal waste disposal will be tremendous—more than 160 acres *annually* for the expected 10,000 megawatts of coal-produced electricity in the

Coal waste blocks being dumped off the New York coast

Coal blocks underwater withstand decomposition


residual oil
low sulfur gas to power plant
ash
sulfur recovery
regenerated limestone
air
retort
spent limestone with sulfur and metals
sulfur
spent limestone
CHEMICALLY ACTIVE FLUID BED

New York area. But in heavily populated areas such as Long Island, New York City, and other areas in the Northeast, the acreage for such disposal simply does not exist; thus, the use of the ocean as a resting place for these wastes becomes an extremely attractive alternative, provided "reef-building" can be done without threat to the marine environment.

Future study of the demonstration reef will involve a periodic assessment of the structure and its environs to determine any environmental impacts, and to measure the development of the biological life associated with the reef. Blocks will also be checked for any changes in their overall structural integrity and their individual density.

EPA Provides Support

When, in 1978, EPA's Office of Air Quality Planning and Standards (OAQPS) required technical support in their development of a New Source Performance Standard (NSPS) for industrial boilers, it called upon EPA's Office of Research and Development for assistance.

The resulting broad-scale research program produced information to characterize and classify industrial boilers and to describe and evaluate the performance of control technologies applicable to the various types of boilers. Additionally, information was produced for emerging technologies, and model industrial boilers were developed. Throughout all of the research, economic and energy consumption data were gathered whenever they were available.

Specific information from the research includes technology assessments of oil cleaning, coal cleaning and low-sulfur coal, synthetic fuels, fluidized-bed combustion, NO_X combustion modification, NO_X flue gas treatment, particulate collection, and flue gas desulfurization. Also part of the 1980 effort was the performance evaluation of control technologies over a thirty-day period. Two wet flue gas desulfurization systems were evaluated, as were seven NO_X combustion modification units. These evaluations, which will continue, should contribute significantly to OAQPS decisions in the development of standards involving these controls.

The detailed research data were published in nine Individual Technology Assessment Reports, as well as a number of other related reports and studies. A summary of the data in a comprehensive background document will be published by OAQPS.

Converting Oil and Coal to Gas

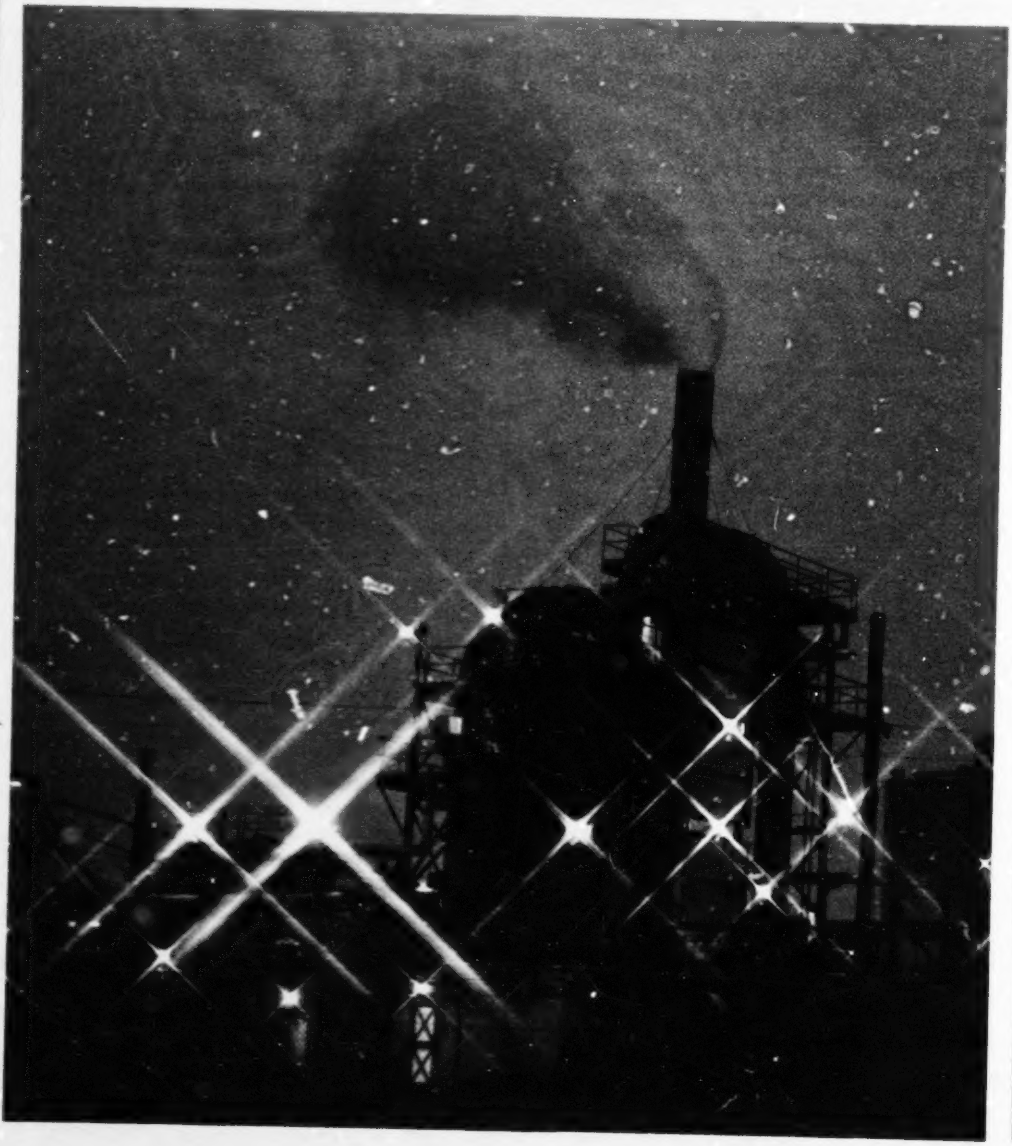
Power plants designed to burn natural gas are smaller, cleaner, and less expensive to build than those designed for oil or coal; consequently, when gas supplies were readily available to power plants and heavy industry in the past, a substantial number of "gas only" plants were built. But now, as the supplies of natural gas to industry are becoming less available, owners of the plants have some hard choices to make—retire the gas-fired plant and build a new coal- or oil-fired one, convert the old plant so it can burn coal or oil, or find some new supply of energy. Through EPA's research, however, another option is becoming available.

In 1980, EPA demonstrated a new process that makes possible the burning of low-grade oil in a power plant boiler designed for natural gas, while at the same time accomplishing a 70- to 90-percent removal of the oil's sulfur content.

The demonstration took place at a Central Power and Light commercial power plant in Texas, where, in a three-hour test, the process generated 22 megawatts of electricity, enough to supply the electrical needs of 11,000 homes. At the heart of the test was an experimental "Chemically Active Fluidized Bed" (CAFB), an advanced fossil fuel technology capable of converting a heavy, high-sulfur residual oil to a low-sulfur gas. The oil used in the test was a number 6 oil, semi-solid at room temperature, and because of heating and pumping requirements, ordinarily limited primarily to use by heavy industry.

While the test burn was only conducted for three hours, researchers indicate that the generation of 22 megawatts is an ample demonstration of the process' commercial capability. The facility was also run intermittently for about 500 hours at an output of about 10 megawatts.

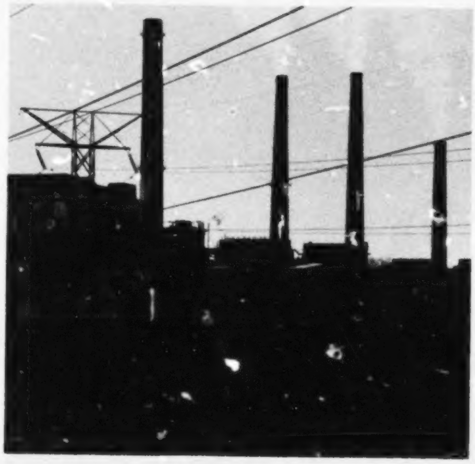
Late in 1980 and early in 1981, the unit will be tested using lignite and eastern United States coals. It is expected that these tests will demonstrate the viability of the CAFB to generate electricity in an environmentally sound manner in units designed originally for "gas only." If successful, these tests will further increase the fuel-switching options open to owners of such power plants.



Japanese NO_X Control

Nitrogen oxides (NO_X) pollution is not only a problem in the United States, it is an issue in most other industrialized nations where large amounts of fossil fuels are burned. In Japan, where NO_X pollution is a very serious problem, technological advances have been made to reduce NO_X emissions; in fact, the Japanese technology that is now operational surpasses similar technology in this country. EPA, realizing that the Japanese equipment might offer workable solutions to our NO_X problems, arranged to have a team of scientists visit Japan. During 1980, the scientists travelled to Japan to study the progress being made in the control of NO_X from large-scale oil-and gas-fired utility boilers. Control is accomplished by the treatment of NO_X with a catalyst in the presence of ammonia. The boilers were being successfully operated at greater than 80% NO_X removal. Research, development, and testing are underway for applications of the technology to coal-fired boilers. Three such large coal-fired units are under construction and will be completed within the year.

Reliability of existing units was reported to be very high, and maintenance very low, with only a cleaning of the air preheater required during the annual boiler shutdown.



Guarantees of catalyst life were found to be usually one year for coal, 2 years for oil, and 3 years for gas-fired applications. Plans for disposal of spent catalyst were not clear at the time of the visit.

Of special interest to the EPA team was the decision by the Japanese to go to 80% removal, versus the 90% or more the de-NO_X system is capable of. Though it was never directly stated, discussions with utility personnel indicated that the 80% figure was settled on as the optimal control level since it minimized catalyst, reactor, and ammonia costs, and downstream problems caused by ammonia emissions.

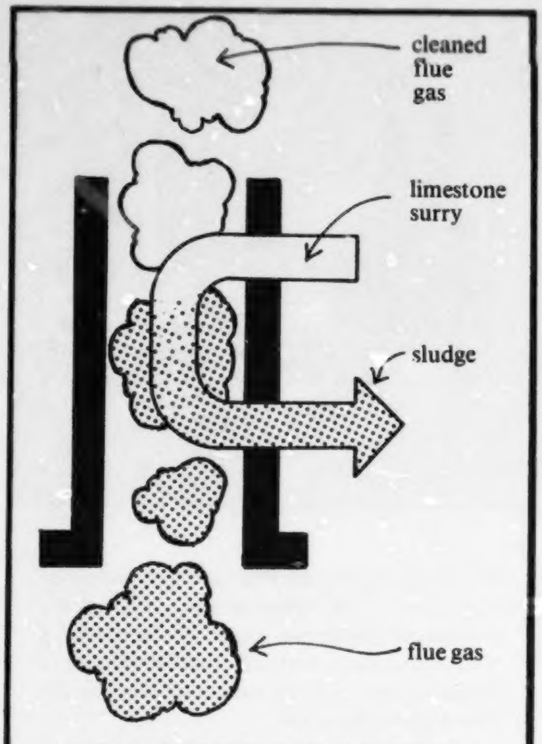
Automated Sulfur Removal

Today, one method of removing sulfur dioxide (SO_2) from flue gases is by wet limestone scrubbing. Here the burner exhausts are brought into contact with a limestone slurry which removes the SO_2 in the flue gases by means of a chemical reaction. Currently under study at EPA are methods to automate the control of this process thereby making it more reliable and less expensive in operation. In addition, automatic control would reduce fluctuations in the process variables including the amount of SO_2 being introduced into the scrubber at any one time. One technique recently tested by EPA involved automating the rate at which limestone is added to the scrubber slurry in order to maintain a constant pH of the system, one of the keys to efficient operation.

In preparation for the test, control loops crucial to the performance of limestone slurries were identified, mathematically modeled, and simulated on a computer to evaluate their dynamics. Results of this study indicated that the SO_2 removal process was generally a linear one, and that relatively low pH levels in the slurry would optimize the chemical reaction between the limestone and the SO_2. Supplementing this detailed research finding was the demonstration that, on the whole, the scrubber itself was a stable process.

It was concluded that by automatically regulating the amount of limestone delivered to the slurry so as to maintain a low and constant pH level within a narrow range, there would be better alkali utilization and higher system reliability. This enhanced reliability would be due to a reduction in internal scaling by sulfites and sulfates, a phenomenon that usually accompanies higher pH levels. Also, with pH levels being kept constant by the automated delivery of limestone to the slurry, variations in SO_2 loadings could be easily accommodated by a greater or lesser input of the limestone depending upon whether the SO_2 loads increased or decreased.

During the test of the pH control system in September, 1980, both scrubber stability and reliability were shown to be improved through use of the automated limestone delivery process. Success of the system indicated that a crucial step had been taken toward the development of a coordinated wet scrubbing system capable of accommodating complicated process disturbances and adapting to changing process conditions to maintain scrubber performance.



WET LIMESTONE SCRUBBING

Precipitator Dilemma

Electrostatic precipitators are the most widely used air pollution control devices for removing particles from coal-burning emissions. They work by imparting an electric charge to flyash particles, causing them to collect on electrodes rather than escape into the atmosphere. Precipitators have been proven under demanding conditions at facilities burning high-sulfur eastern coal. Yet when these devices are used where low-sulfur coals are burned, their ability to capture flyash becomes significantly impaired. This presents an environmental dilemma with existing precipitators: Reducing sulfur emissions can increase particle emissions.

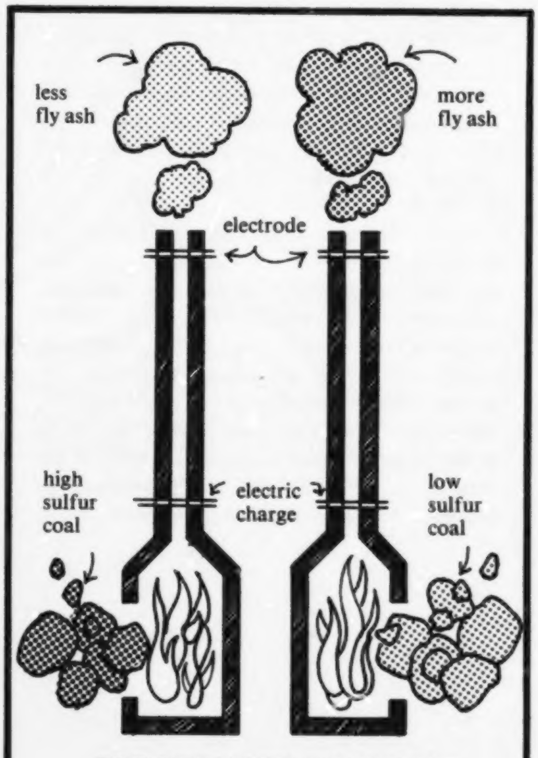
The reason for this dilemma is that at normal operating temperatures the collection efficiency of a precipitator is directly proportional to the amount of sulfur in the coal; the lower the sulfur content, the less efficient the collection of flyash. One alternative to this problem—compounded by the increased burning of low-sulfur coals—is for coal-burning facilities to use larger electrostatic precipitators which could effectively reduce particulate emissions from low-sulfur coal. But this is a costly, space-consuming option.

As a second alternative, industry attempted to solve the problem by operating its precipitators at higher than normal temperatures, temperatures at which performance was not dependent on the coal's sulfur content. Results of these efforts, however, demonstrated that the high temperature technique was not as effective as anticipated.

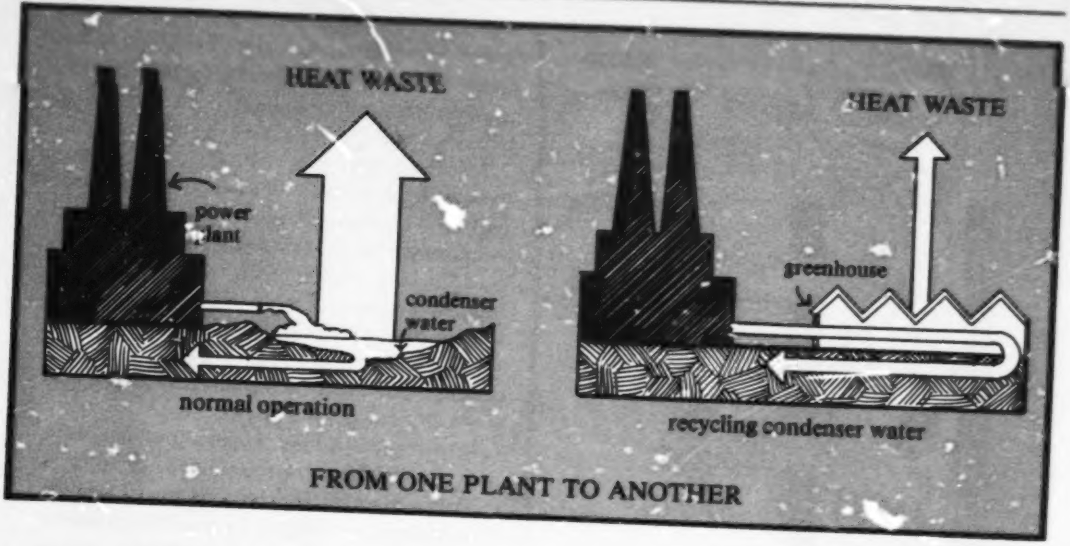
A subsequent joint EPA-industry venture recently developed a fix for this poor performance problem. The solution involved the addition of sodium sulfate to the low-sulfur coal before it was burned. In a 1980 demonstration project in Florida, addition of only modest amounts of sodium sulfate resulted in a 500% improvement of flyash removal. Under normal operating conditions the cost of this addition would only be about 20 cents per ton of coal.

Use of the compound should also eliminate the need for washing precipitators being used in conjunction with boilers burning low-sulfur coal. This washing, now required every 30 to 60 days to remove flyash residue that drastically reduces electricity flow, necessitates the complete shutdown of the precipitator unit.

The demonstration study continues into 1981 to determine whether the addition of the sodium sulfate causes any adverse effects to the boiler. Also being evaluated are any long-term effects on precipitator operation, and the applicability of the procedure for other ash chemistries.



PRECIPITATOR DILEMMA



Energy from One Plant to Another

By piping warm condenser water from an electric power generating plant to nearby commercial greenhouses, northern U.S. greenhouse operators can cut annual fuel costs by about $25,000 per acre (based on #2 fuel oil at $1.00/gal) and can save dramatic amounts of fuel. This was a key finding of an EPA study that took place near Minneapolis, Minnesota where the heated condenser cooling water of a power plant was pumped approximately one-half mile to heat both the soil and the interior air of a demonstration greenhouse. Roses and tomatoes, the principal crops raised in the study, fared extremely well. Snapdragons, geraniums, lettuce, and evergreen seedlings were also grown successfully, thriving as outside temperatures fell as low as −40° F.

Economic success or failure of using the condenser water, however, was shown to be very site-specific. Factors that influence the economics and therefore that must be taken into consideration include local weather and market conditions, location of a given greenhouse relative to the market place, availability of competitive goods, and shipping charges. Thus, while the study demonstrated the technological feasibility of the process, it was only able to demonstrate its economic viability in this single instance. However, so convincing were the data that, following conclusion of the demonstration, one of the commercial greenhouse owners doubled the size of his operation to take even fuller advantage of the inexpensive heating source afforded by the power-generating plant.

Late in 1980, a related study was initiated to determine whether waste heat from the Northern States Power Company's Sherco Plant could be used for a fish hatchery.

The following EPA research components contributed to the research described above:

- Office of Environmental Engineering and Technology—Industrial Environmental Research Laboratory, Research Triangle Park
- Office of Health Research—Health Effects Research Laboratories, Research Triangle Park and Cincinnati

OIL AND GAS FROM COAL

As the age of synthetic fuels draws closer, EPA is intensifying investigations of potential synfuels pollutants.

As the age of synthetic fuels in the United States rapidly approaches, research into the environmental effects of such energy production also progresses. The key words pervading this research are "prediction" and "prevention." As is the case with any major new technology, EPA is anxious to know what environmental threats or degradation to expect.Once known, work then shifts to averting this potential damage, or at least to minimizing it.

In 1980, four studies highlight this effort. Two involve environmental assessments at operational gasification facilities abroad. The other two were performed in the United States—one at an EPA pilot-scale gas cleaning facility at North Carolina State University, and the other in Texas where an EPA subcontractor has developed a device capable of assessing secondary air pollutants from a variety of new fuel conversion facilities.

Gasification Data from Foreign Sources

Commercial-scale coal gasification plants are likely to become realities in the nation's energy future; such plants, however, have been operating for years in other countries. EPA, realizing that these foreign plants offer an "operational" look at the environmental problems that may come from the future American plants, was able to arrange a data-gathering research effort in Modderfontein, South Africa, the location of a commercial-scale, Koppers-Totzek coal gasification facility. The plant's treated and untreated wastewater streams were studied, and gas analyses were made during plant operations.

Preliminary results of the study revealed that plant wastewater streams had a low organic content since most organics cannot survive the high operating temperature of the Koppers-Totzek process. Phenol levels were also low, comprising less than 1 mg/l of the wastewater sample. Notably, following simple treatment in a clarifier and a settling pond, the plant's final discharge was quite similar to the water initially fed into the process.

Samples of condensates from raw gas compression units and acid gas removal units, however, contained metals at concentrations exceeding Discharge Multimedia Environmental Goals (DMEGs). These excesses, it was postulated, were the result of the high ash content (19% by weight) of the coal being gasified.

Based on the limited testing, the data obtained at Modderfontein indicates that similar plants constructed in the U.S. could be designed to effectively control the quality of their wastewater. The lower ash content of the coal most likely to be gasified at U.S. facilities should also reduce the amount of heavy metals condensed out of Koppers-Totzek process gases.

Synfuels Air Pollution Controls

Energy conversion technologies being developed today must take into account emission limits required to protect the air quality of tomorrow. The current problem is that the pollutants generated by a given process must be adequately identified before control measures can be integrated into synfuel plant designs. Thus, what is needed now—before major costs are incurred and before emission control designs are finalized—is hard information on precisely what air pollutants will be produced, how atmospheric chemical reactions will change the initial state of the pollutants, and how those pollutants will ultimately manifest themselves in the environment.

The reactions a pollutant can undergo when exposed to sunlight, humidity, and other substances in the atmosphere are complex and difficult to predict. But this information is important to environmental regulators; if the pollutant turns into a harmless substance there will be less need to control it than if it becomes toxic or hazardous. Until recently, there was only one accurate way to monitor a pollutant as it travelled through the atmosphere—follow it in an airplane and take periodic samples. As can be imagined, this method is expensive, and its utility is limited to existing major sources of emissions.

We needed a better way to predict pollutant transformations under realistic atmospheric conditions. A major step in this direction was taken by EPA in 1980 with the initial testing of its Mobile Aerosol Reaction Chamber (MARC), designed to assess the secondary pollutants,

The MARC sampling room is fully instrumented

Mobile Aerosol Reaction Chamber
U.S. Environmental Protection Agency
Environmental Sciences Research Lab
Research Triangle Park, NC 27711

MARC is completely mobile

particularly aerosols, that may be produced by emerging commercial fuel conversion technologies. Far more versatile and reliable than conventional aircraft sampling procedures, the MARC system can be transported to the site of a pilot-scale fuel conversion facility. Process pollutants are then pumped into the MARC chamber where they can be exposed to a variety of simulated atmospheric conditions. With the control the system affords, the potential of these emissions to form secondary pollutants under such conditions can be explored, after which these secondary products can be collected and analyzed.

The actual MARC chamber is an 800-cubic foot Teflon bag lit by 216 ultraviolet lamps capable of simulating the noonday sun. The chamber is housed in a 40-foot-long trailer for easy transport to coal conversion test sites. The trailer is both heated and air conditioned so that chamber temperature can be fully regulated. In its normal operating mode, process and emissions streams will be continuously introduced into the chamber via a sample line, and partially diluted by air from a clean air generator; product removal will also be continuous. Optimally, the chamber may also be used to hold batches of reactant gases, delivered with or without diluting fresh air. In addition, the system has its own ozone generator, and bottled gases to allow controlled additions of specific pollutants to the reaction chamber. Ultraviolet light intensity may be varied, as may reaction time in the chamber, concentration, and type of reaction pollutant added to the test stream, relative humidity, mixing rate, temperature, and other process variables.

Far more than a bag with lamps and gas containers, MARC has at its heart an extensive monitoring and analysis system, operated by a microprocessor. This microprocessor controls the flow of the process stream as it enters and exits the reaction chamber, making attainment of steady state reaction conditions and secondary aerosol information possible. Every ten minutes, inlet and outlet streams are alternately analyzed for sulfur dioxide, nitrogen oxides, ozone, aerosol particle size distribution, total nuclei concentration, temperature, pressure, relative humidity, gas flow rate, and ultraviolet radiation. The microprocessor also averages sample times, records, stores, and prints out all the process and analytical data.

What MARC brings to the designers of new energy technologies is an accurate, non-theoretical, real-world sense of precisely what secondary aerosols will be formed as a result of synfuel process streams and in what relative quantities. The information is also specific to the technology itself, rather than data from conventional ambient air pollution monitoring studies which are not capable of isolating single sources.

A full characterization study of the reactor to include tracer and mixing studies, classical smog chamber reactions, light and dark phase reactions, and reactive hydrocarbon studies, is scheduled for the immediate future. Test results will be compared to those reached in earlier work using less sophisticated smog chamber systems.

Currently, MARC is scheduled for testing during 1981 and 1982 at a series of advanced fossil fuel conversion and combustion facilities including coal gasification, liquefaction, and fluidized bed combustion plants. The MARC project may also be expanded to include construction and operation of an exposure chamber that would make use of product gases from MARC for a series of bioassay studies.

With such advanced, mobile equipment, we are approaching the point at which determinations can be made, with a reasonable degree of accuracy, of the actual health and environmental impacts of a specific technology under known conditions. Such a capability would bring dramatic new precision to the environmental decision-making process.

Yugoslavian Coal Gasification

A three-year study undertaken by EPA at a commercial-scale, medium-BTU Lurgi coal gasification complex in Kosovo, Yugoslavia, found significant concentrations of organics contained in Lurgi process condensates and major waste streams. Phenol concentrations in major wastestreams were found to be relatively low, however, and in analyses of by-product streams, sulfur concentrations of light gasification by-products (e.g., gasoline) were revealed to be significantly higher than that of the heavier by-products streams (e.g., tar).

Part of the research and a major focus of the study was an assessment of ambient air quality in the Kosovo Region. Five sampling sites were established around and approximately two kilometers outside the fenceline of the Kosovo facility. Sampling was conducted continuously over a sixteen-day period with state-of-the-art techniques including ion chromatography, scanning electron microscopy and X-ray emissions employed for sample analysis. A comprehensive quality assurance and quality control program was also implemented to ensure the validity of the samples collected and analyzed.

It was found that total atmospheric particle loads were higher immediately downwind of the complex, with coal dust from coal handling, grinding, and transport thought to be the major contributor. Found as a vapor and adsorbed on downwind particulate matter was a complex organic mixture, the most important elements of which were benzene and benzo(a)pyrene. Levels of these organics in the ambient air two kilometers downwind of the plant were found to exceed target Ambient-Multimedia Environmental Goal (A-MEG) values by a factor of 10-100 and 1000 respectively. Also identified as major pollutants of concern were methyl and ethyl mercaptans, carbon monoxide, hydrogen sulfide, and ammonia.

Poland
USSR
Czech
Germany
Austria
Hungary
Romania
Yugoslavia
Italy
Kosovo
Bulgari
ania
Greece
Sicily

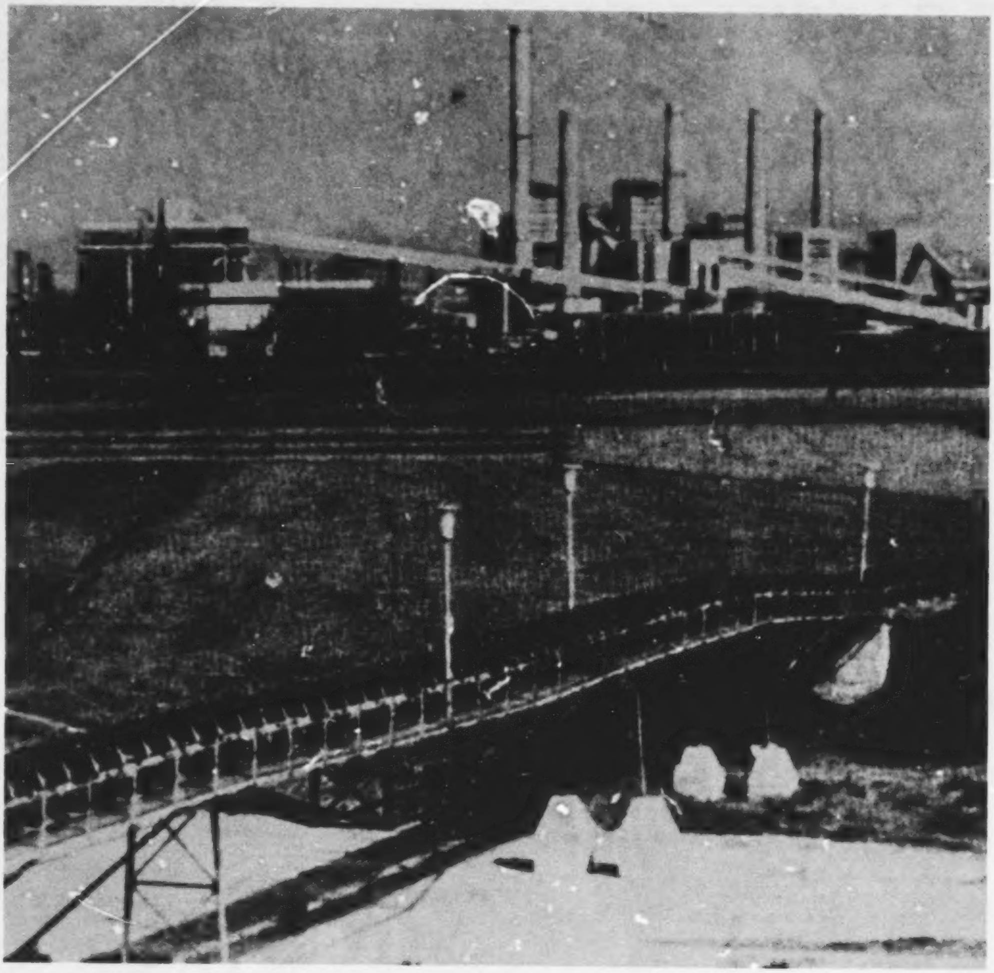
Overall, the study resulted in the identification and quantification of all the major pollutants of the Kosovo air and water discharge streams. Pollutants were also ranked according to their potential for environmental damage. Results from this effort led to the conclusion that all the plant's uncontrolled discharges presented *significant potential* for posing threats to human health and the environment, and that effective controls for several individual or combined discharge streams would be imperative for planned U.S. commercial facilities, which are expected to be ten times the size of the Kosovo plant.

Anticipating future development of Lurgi process gasification systems in the U.S., EPA is currently making use of the Kosovo study data to help identify those areas where pollution controls or process adjustments will need to be considered. If sound environmental controls are designed into U.S. plants, this can often be done at considerably less expense than if such controls are added after the fact.

Identification of Potential Synfuels Pollutants

In support of U.S. synfuel development, in 1980 EPA also conducted extensive research in North Carolina into the pollutants that may result from such facilities. One study used a laboratory-scale gasifier to identify and rank the contaminants found in the ash residue, raw product gas, aqueous condensate and tars produced by coal gasification. The purpose of this research is to quantify the amounts of the trace and minor contaminants found in gasifier process streams so they are not overlooked in the evaluation of pollution control devices. Most of the devices now being designed are primarily for treatment or removal of only the major contaminants.

Another highlight of the 1980 research effort was a compilation of the chemical constituents formed in the gasification of coal, many of which



The Kosovo plant

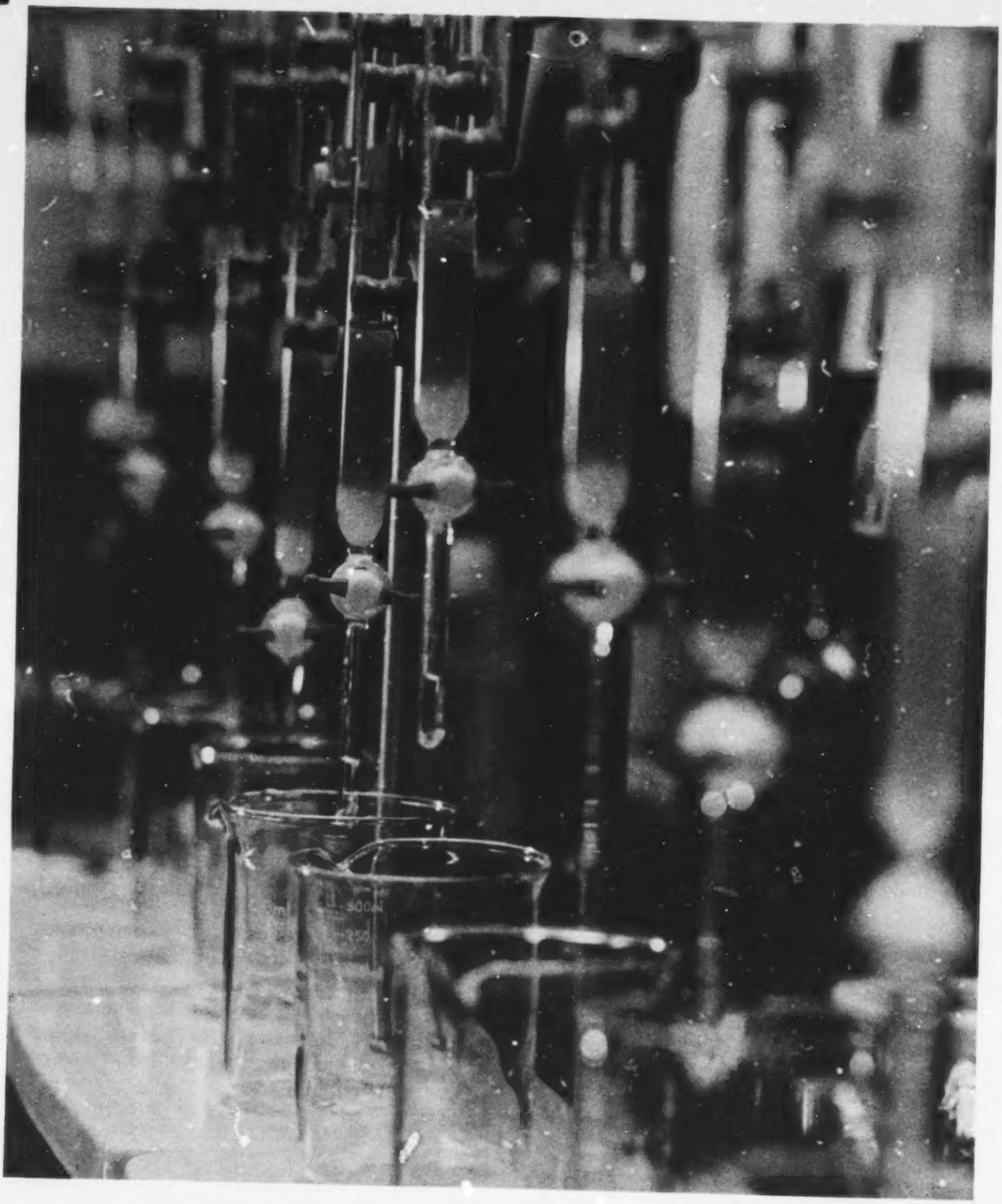
are noted for their toxic properties and/or for causing ecological damage. However, different gasification processes produce different chemical products; therefore compounds from tests of a variety of coal gasifiers were included in the compilation. Chemicals were then ranked on the combined basis of their toxic properties and concentrations in gasifier process streams.

Research Triangle Park, North Carolina was also the scene of a 1980 study to determine the relative influence of coal types and of operating conditions upon waste stream composition. Nine different coals were tested. Results indicated that regardless of the type of coal fed to the gasifier, the same general pattern of chemical substances was produced, and that the nature and actual concentrations of the stream components were much more dependent upon a gasifier's operating conditions—steam-to-air ratios, pressure, temperature, and gasifier configuration, etc.—than on the coal.

Another highlight of the 1980 research effort was a series of tar sample bioassays. Results of these studies indicated that tar's organic base constituents possess a high potential to cause mutagenic changes, and that moderate-to-high mutagenic potential is also present in tar's polynuclear aromatic hydrocarbons and components found in its polar neutral fraction. These findings, in concurrence with findings of related studies done elsewhere, will help in setting future coal gasification monitoring requirements, in the establishment of regulations and in the development of synfuel control technologies.

The following EPA research components contributed to the research described above:
- Office of Environmental Processes and Effects Research—Environmental Sciences Research Laboratory, Research Triangle Park
- Office of Environmental Engineering and Technology—Industrial Environmental Research Laboratory, Research Triangle Park
- Office of Health Research—Health Effects Research Laboratory, Research Triangle Park

HEALTH EFFECTS



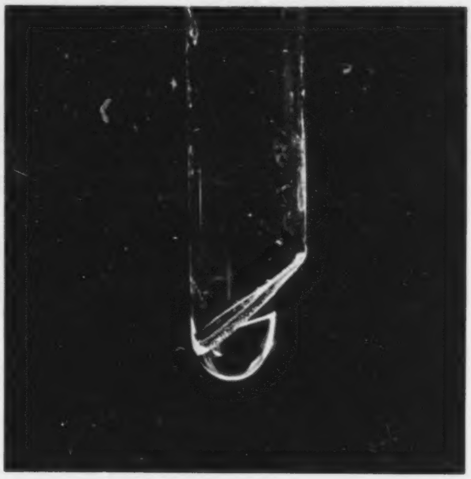
EPA's health effects research is revealing many potential hazards people are subjected to by environmental pollutants.

With the exception of a few wild beasts and poisonous plants, a truly natural environment is a pretty healthy place. The air is clean, the water is fresh, and the food is uncontaminated. Such an environment exists only in a few isolated places. It may soon exist only in our imagination. The effluents of our modern industry are everywhere. The snow that falls on Antarctica contains a number of man-made chemicals, as do most drinking water supplies and every breath we take.

Some of these alien substances are harmless. Others may pose threats to our health serious enough to require monitoring and/or control. Identifying these harmful substances, their location, the dangers they pose, the manner in which people are exposed to them, and the potentially adverse effects from the exposure—these are some of the issues being illuminated by EPA's research into human health effects.

Genetic Damage To The Embryo

During 1980, EPA health effects research has cast significant new light on the potential for certain compounds associated with cancer or birth defects to cause genetic alterations in the embryo. This was accomplished through use of sister chromatid exchange (SCE) analysis, which enables researchers to detect chromosome changes in specific tissues after the tissues have been exposed to suspect chemicals.



SCE analysis involves observation of the level at which chromosome segments are swapped between the two arms, or sister chromatids, of a chromosome. Under normal experimental conditions, such exchange takes place at low levels; in the presence of certain test chemicals, however, the level of exchange is increased. This increase provides a very sensitive indication of genetic activity by the test chemical. Such chemically induced effects are particularly noteworthy in light of the fact that chromosomes carry the blueprint which determines each organism's final makeup.

Both experimental animals and rodent embryos growing in culture were used for the EPA tests.

Working behind a glass hood protects EPA researchers from carcinogenic materials

Specific embryo tissue analysis was performed on pregnant rats and mice following their exposure to chemical test agents and the transplacental passage of the substances and/or their metabolite(s) to developing embryos. Results of the testing revealed embryo SCE levels up to 10 times the normal frequency, thus indicating that the chemicals were capable of exerting significant genetic effects. Some of the chemicals shown to be genetically active in the animal testing, however, were relatively inactive when applied to embryos growing in culture. These results point to the importance of maternal processes on the metabolism of certain compounds. In other words, in some cases the bodily processes of the mother may take a (genetically) relatively inactive substance, activate it, and then expose the embryo(s) she is carrying to this far more genetically active agent.

Through the use of SCE analysis the relative genetic potency of various chemicals and suspect metabolites can be determined. It is also thought that the system will prove particularly useful for tracking the transport of genetically active substances to the embryo and determining specific tissue effects. Future work involves further study of the relationships that exist between chemical damage and maternal-embryo interactions concerning a variety of embryo tissues.

Measuring Genetic Damage

It has been estimated that a large proportion of human disease results from mutations in the human genetic material. The two types of mutations that occur in human genetic material take place either in a single gene, a point mutation, or in a whole chromosome. Mutations of the germinal tissue can be passed on to subsequent generations, while mutations in other body tissue are thought to be able to cause the development of cancer.

To assess the potential of particular compounds to cause damage to genetic material, a large number of short-term *in vitro* assays have been developed. However, before the information derived in these assays can be effectively used to predict the consequences of human exposure to a particular compound, it is crucial that each test system be characterized, that is, understood as to the type of genetic events, or mutations, detected and the factors that might affect their detection.

During 1980, EPA researchers evaluated one such system, the L5178Y/TK$^{+/-}$ mouse lymphoma, an *in vitro* mammalian assay. A number of mutants produced by this assay were analyzed for the presence of chromosomal mutations. Studies to date indicated that some of the mutants apparently resulted from mutations within single

genes, while others resulted from alterations of whole chromosomes.

If overall study findings do, in fact, indicate that both these forms of genetic damage can be detected by the mouse lymphoma assay, then the technique will be the first *in vitro* mammalian bioassay proven to be able to detect simultaneously both kinds of genetic mutations which occur in man.

Systemic Effects of Common Air Pollutants

The human "xenobiotic metabolism" system has charge of processing the foreign chemicals that find their way into the body. In some instances the system metabolizes substances into less toxic compounds. Other times, however, the opposite may be true; some carcinogens, for example, not particularly potent themselves, may be activated by the system into more carcinogenic forms. The response of the xenobiotic metabolism system to ambient concentrations of ozone and nitrogen dioxide, two ubiquitous air pollutants, was the subject of a 1980 health effects study by EPA.

Prompting this research was the already demonstrated effect that these two pollutants increased pentobarbital-induced sleep time in female mice; the premise being that the increased sleeping time was a manifestation of a decrease in xenobiotic metabolism system rates; *and* that the effects of these gases was systemic—capable of affecting the whole body—not only the lungs, as has been previously believed.

Results of the research indicate that:

—female mice, rats, and hamsters all experienced a significant increase in pentobarbital-induced sleeping time after acute exposure to ozone; however, males of these species experienced a lesser response;

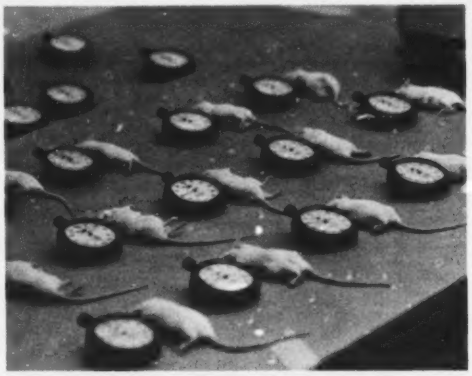
—female mice were also more affected by nitrogen dioxide than male mice;

—as concentrations of ozone decreased to common urban levels, an increasing number of daily exposures was required to produce the increased sleeping time effect;

—however, with nitrogen dioxide, increased sleeping time occurred after a single common urban level exposure; thus, for this particular study, nitrogen dioxide was more toxic, an unusual finding.

The study also indicated that ozone caused a decrease in the ability of the brain and plasma to clear itself of the pentobarbital, and, perhaps most important, that the inhalation of ozone can affect the metabolic rates of parts of the body other than the lungs—the liver, for example.

The implications to humans of study results can only be guessed at at this time. The possibility exists that these pollutants can alter the human xenobiotic metabolism system, particularly in women. And if they can alter the metabolism of pentobarbital, it is also possible that they can affect the metabolism of other drugs and toxic chemicals. Finally, if these gases may affect organs other than the lungs in animals, it is indeed possible that their overall effects in humans may also be systemic, thus pointing to a need for the study of their effects on a wide variety of human organs.



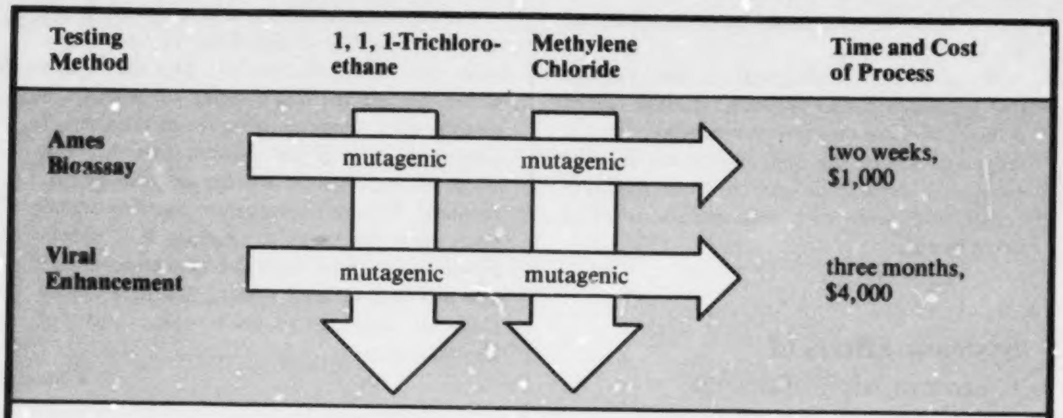
Recovery time of mice given pentobarbital varies with exposure to different air pollutants

Cells Unaffected by Microwaves

1980 marked the culmination of a four-year study undertaken by EPA's Office of Research and Development to determine whether genetic and cellular changes occurred in single-celled organisms when exposed to selected frequencies of microwave radiation common in our daily lives. Several strains of bacteria and yeast were used in the research. Also studied were the effects of increases in temperature on the test organisms. Such temperature increases accompany higher microwave power levels, and are known to be lethal to certain yeast and bacteria cell strains.

Results of the study are included in a recently published 33-page EPA report entitled "Genetic and Cellular Effects of Microwave Radiation." Of note, the report states that the studies revealed no increases in mutations or gene conversions in cells exposed to various levels of microwave radiation.

Soviet and Eastern European research on the biological effects of microwaves has already resulted in the setting of strict microwave public standards in those countries. Whether similar strict regulations are needed in this country will, to a large extent, be determined by this study and other research currently underway at EPA and other agencies.



EPA-DEVELOPED TESTING PROCEDURES

Testing Volatile Agents

In 1980, a procedure developed by EPA researchers made possible the testing of mutagenicity and carcinogenicity of two volatile liquids of particular concern to EPA's Office of Air Quality Planning and Standards. The liquids tested were two chlorinated organics—1,1,1-trichloroethane and methylene chloride. The tests utilized were the Ames *Salmonella typhimurium* bioassay and the Casto viral enhancement assay. The Ames bioassay measures the ability of a test chemical to induce gene mutations in bacteria; the viral enhancement assay predicts the carcinogenicity of a test agent.

In both tests, indicator organisms, either bacterial or mammalian cells, were placed into incubation chambers to which the test agent was introduced. The chambers were then sealed. After appropriate exposure times, the test organisms were removed and placed into growth chambers where any genetic effects could be made manifest.

Results of the Ames bioassay indicated that both liquids were mutagenic, with each compound demonstrating greater mutagenicity as doses were increased. Both compounds also gave positive responses in the viral enhancement test. Using these procedures it is estimated that the Ames test could be performed for a given compound in a period of two weeks at a cost of $1000. The viral enhancement test would take 3 months to perform at a cost of $4000 per sample. This compares favorably with other common laboratory mutagenicity and carcinogenicity test methods which may cost far more and take longer to perform. Prior to this methodology, for instance, the only way to predict whether a gaseous or volatile substance was a carcinogen would be to perform an inhalation carcinogenesis bioassay; a procedure which would take 10 times as long and cost 100 times as much to perform as the Ames and viral enhancement bioassays.

The faster and less expensive procedure now provides EPA with the capability to expand its testing to a number of volatile liquids and gases previously difficult to evaluate. As more information about these agents is required, as inevitably it will be, these bioassays will be able to quickly provide the answers.

The following EPA research components contributed to the research described above:
- Office of Health Research—Health Effects Research Laboratory, Research Triangle Park

MODELING

Predicting environmental pollution and supplying data to solve pollution problems is one goal of EPA's modeling research.

Mathematical and laboratory models play a large role in forecasting possible environmental futures. The mathematical models are usually a series of equations programmed into a computer; the laboratory models can range from an enclosed microcosm of a plant community to fish tanks holding the components of an aquatic ecosystem.

With the models, researchers can vary the environmental conditions to see how the model responds, thus allowing for a prediction of how the real environment might respond to similar conditions. A chemical spill, a decrease in ambient temperature, an increase in air pollution—projects on the grandest scale can be tested with the models, yet nothing is risked. But what is learned may help not only in the protection of human health and the environment but may also assist in determining the best, most cost-effective means to defuse future environmental problems now.

EPA's research office has been working with predictive models for years. Those discussed here are just some which have produced significant findings in 1980.

New Assessment Procedure

Of the thousands of chemicals found in industrial wastes, which ones pose a threat to human health and the environment and should, therefore, be classified as hazardous? Making this determination is a task given EPA by the Resource Conservation and Recovery Act. In 1980, an assessment procedure developed by EPA's Office of Research and Development enabled 230 potentially hazardous compounds to be screened for their potential to contaminate subsurface and surface waters.

The assessment procedure has, at its heart, models that are based upon what is known about the physical and chemical properties of each compound. Researchers using the modeling techniques were able to estimate the movement and persistence of the compounds under the variety of environmental conditions prevailing in those areas where the compounds were likely to be disposed. From these estimates, each compound could be ranked according to its relative exposure likelihood.

The overall model used for the evaluation was a simple mass balance model that routes each pollutant from the point of entry into the environment, i.e., from a landfill or lagoon, through a series of typical locales or aquatic environments including rivers, small lakes, and reservoirs. Although simple, the model was able to estimate the percentage of pollution inputs that were dissolved in the receiving water, volatilized to the atmosphere, sorbed to sediment, bioaccumulated in fish, or degraded by chemical and biochemical reactions.

In addition to the model predictions for each of the 230 chemicals, EPA researchers conducted a chemical-by-chemical search using Water DROP, the Agency's computerized organic water pollutants library, to determine the extent to which each of the compounds has actually been detected in the nation's surface waters and in finished and unfinished drinking water.

The results of the new assessment procedure were not confined to the laboratory, however. The findings of the analysis of the 230 chemicals provided the technical background for justifying the regulation of 77 types of industrial waste streams. On November 19, 1980, it became law that those waste streams are now subject to regulatory control.

Center for Water Quality Modeling

The use of mathematical models to predict the transport and fate of water contaminants is an integral part of implementing the goals of the Clean Water Act. Water quality planners, managers, and engineers use models for waste load allocation studies, water quality assessments, alternative control option evaluations, and evaluations of proposed water quality management projects and plans. Until recently, however, there was no centralized point where water quality analysts could turn to obtain such models.

Responding to this need, EPA's Office of Research and Development established the Center for Water Quality Modeling at its laboratory in Athens, Georgia. Provided here is access to a central file and distribution point for computer programs and documentation for selected water quality and pollutant loading models. In addition, the Center sponsors workshops and seminars that

EPA hosts seminars for water quality managers provide both generalized training in the use of the models and specific instruction in the application of individual simulation techniques.

Choosing the various modeling packages to be supported by the Center from among the many candidate models required a careful selection process. Of the more than 50 models screened, only four were found to meet the rigorous requirements of the Center. The models were chosen based upon analysis of their utility and effectiveness, availability of adequate documentation, degree of acceptance and application by users, and our own experience with the computer software. We expect the inventory of supported models will grow in future years.

A newsletter provides information on all Center activities including workshops and training opportunities, tips on solving problems encountered by model users, software updates, and announcements of new EPA data of interest to modelers. Such activities help make the expertise of EPA's researchers directly available to the front-line environmental managers.

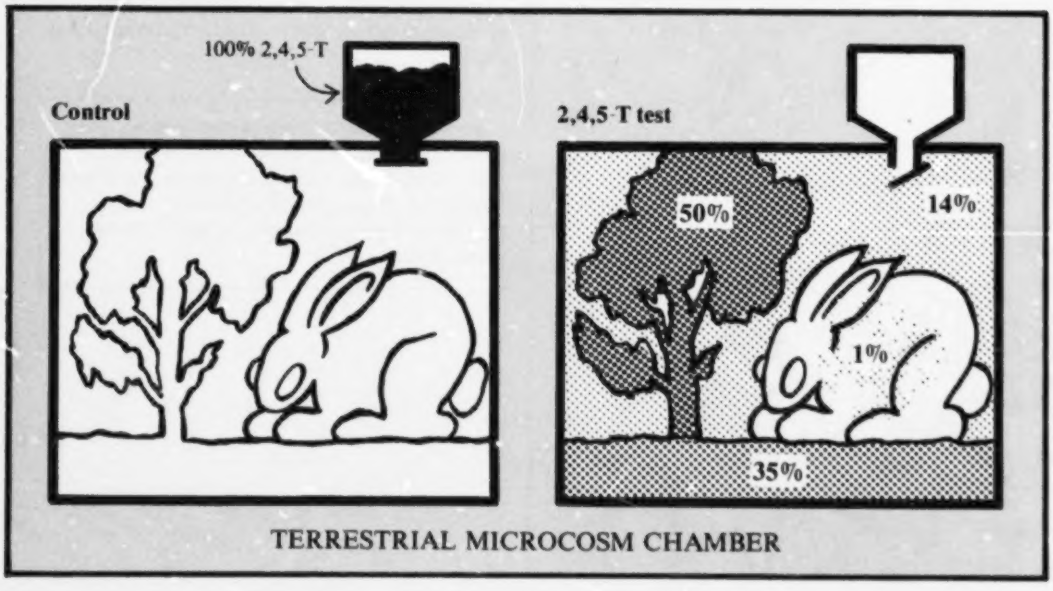
Real Terrestrial Life

Traditional laboratory studies to determine specific aspects of the fate and effects of chemicals in the environment provide part of the answer as to what happens when chemicals are actually released. Such studies are, however, often too far removed from the real world, primarily in their ability to take into account the full variety of interactions that may actually occur. Field studies, on the other hand, provide a full environment; they are the real world. They are, however, costly, potentially harmful to the very environment being tested, and frequently do not allow the researcher sufficient control over the problem being investigated.

A convenient research alternative now available is laboratory microcosms—self-contained miniatures of the actual environment. Here costs and risks are low, situations are controlled, and many actual ecosystem processes are provided. One such microcosm—the terrestrial microcosm chamber—was recently developed by EPA researchers for use in testing commonly used pesticides. Mathematical models developed from these microcosm studies will eventually allow investigators to predict the movement of chemicals within terrestrial systems quickly, at a reduced cost, and at no risk to the outside environment. Both models and the data generated by experiments conducted in the chamber will be of significant use to EPA in its pesticides regulatory efforts.

To date, the terrestrial chamber has been used to test 14 different chemicals including organochlorine and organophosphate insecticides, herbicides, fungicides, and wood preservatives. For example, in recently completed chamber experiments on radioactive 2,4,5-T, results revealed that 20 days after treatment, 50% of the material remained in plants as metabolites, 35% remained in the soil primarily as a metabolite and less than 1% ended up in animals. The rest of the material was volatilized into the air.

While no direct comparative field studies have yet been undertaken to validate the results we get using the microcosm, comparison of our results with existing field data points to the ability of the chamber to duplicate a terrestrial ecosystem in an EPA laboratory.



TERRESTRIAL MICROCOSM CHAMBER

Reference Shrimp

In aquatic models, the quality of the food given the aquatic species can be as important to the final results of the experiments using the model as the model's water temperature or chemical composition. An essential food nourishing many aquatic species in laboratory models today is brine shrimp, *Artemia;* therefore, it is essential that a standardized, or reference, supply is available for brine shrimp or their eggs.

Currently only two sources of supply in the world exist for reference brine shrimp eggs; one is the *Artemia* Reference Center in Ghent, Belgium; the other is EPA's marine biology laboratory in Narragansett, Rhode Island.

The development of the capability to supply reference Artemia eggs came about as an adjunct to the laboratory's research over the last few years in a relatively new science—that of aquatic toxicology. In this kind of research living aquatic organisms are exposed to pollutants and subjected to bioassays in an attempt to draw broader conclusions about the toxicity of the pollutant compounds and their effects on humans and the greater environment. Since what these organisms eat is integral to the results they will produce in these bioassays, live food sources such as the brine shrimp needed to be assayed as well to ensure standardized hatchability, biochemical composition, and nutritional value. The year 1980 saw the establishment of a stock of reference eggs in Narragansett. As the present-day keeper of these eggs, the laboratory plays a vital role in the success or failure of aquatic toxicology studies at EPA and elsewhere.

An international research project (partially funded by EPA), involving five laboratories in four countries, serves to demonstrate precisely how important these reference eggs are. To evaluate a number of different strains of commercially available *Artemia* as food for marine species, researchers studied brine shrimp strains from Australia, Brazil, Italy, and the United States. Based on the group findings, laboratory aquatic organisms fed Australian, Brazilian, Italian, and reference brine shrimp had high survival, while animals fed *Artemia* hatched from each of two harvest sites in this country experienced substantial mortality. Growth of animals fed the various *Artemia* also differed greatly.

With the reference strain now developed, laboratories performing aquatic toxicology studies need no longer concern themselves with mortality or changes in growth caused by inferior strains of brine shrimp and can be assured that the quality of biological research data will be improved and that potential comparability of this data with that from other laboratories will be greatly enhanced.

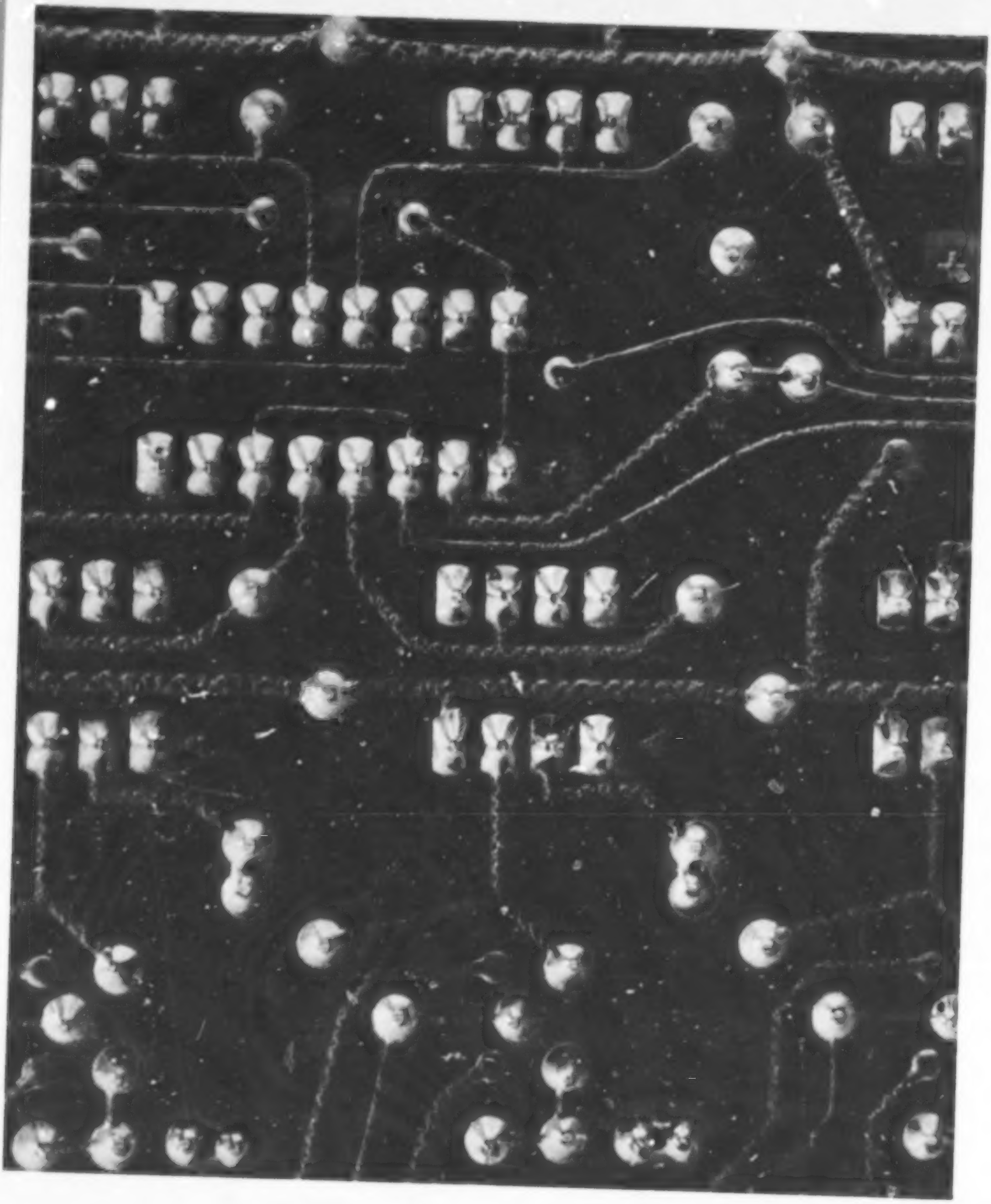
The following EPA research components contributed to the research described above:
- Office of Environmental Processes and Effects Research—Environmental Research Laboratories, Narragansett, Athens, Corvallis, and Duluth

Brine shrimp eggs (magnified)

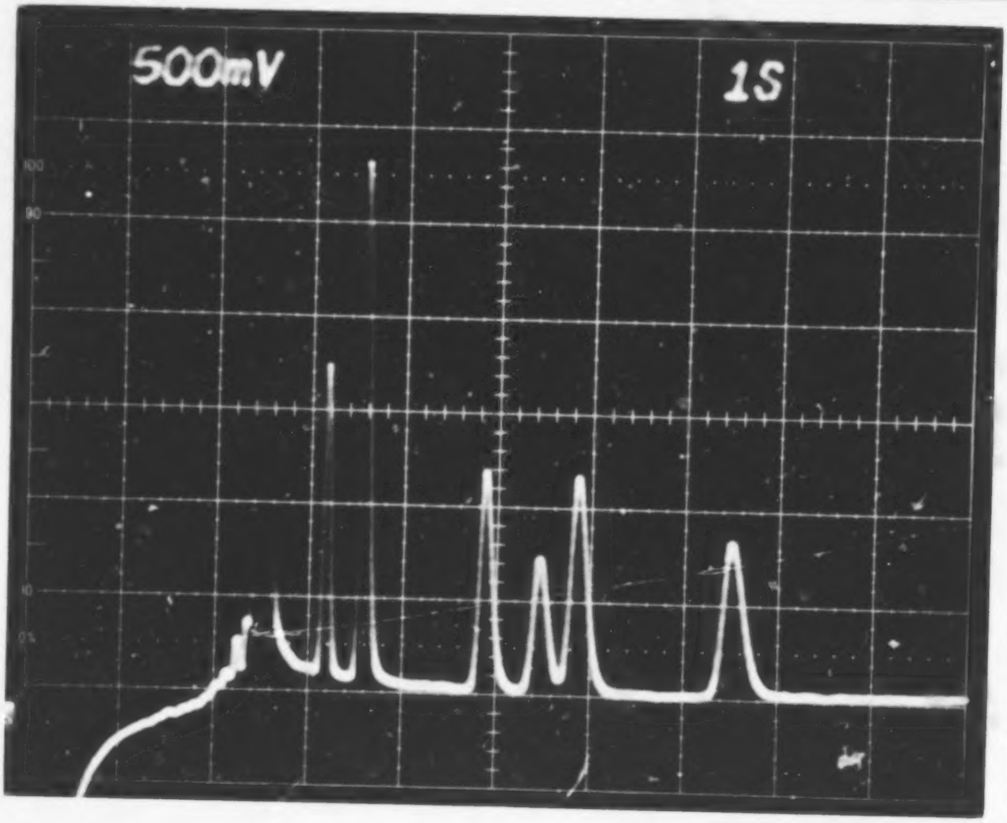
Brine shrimp

Gathering shrimp

NEW TECHNOLOGY



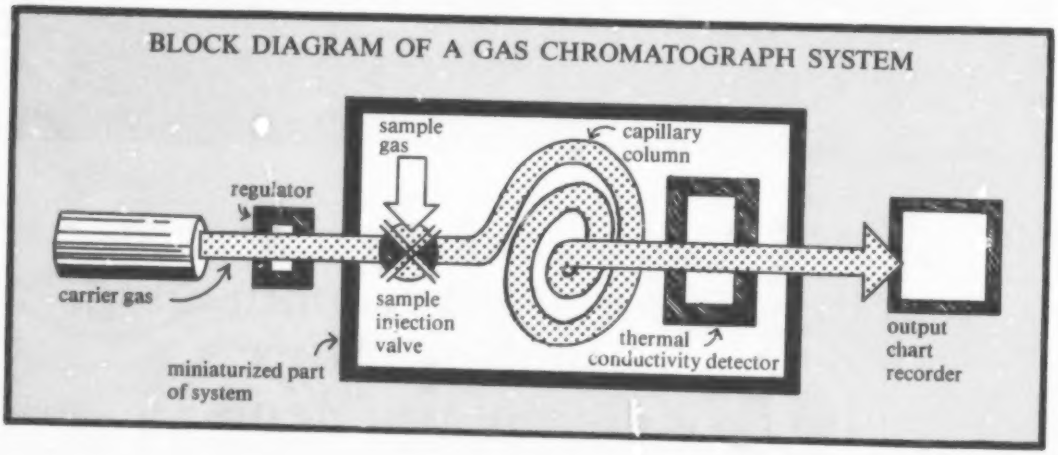
EPA's new technology research will help in monitoring, managing, and controlling future environmental problems.



Different chemicals cause characteristic spikes on the miniature gas chromatograph

If there is one lesson that environmental contaminants should have taught us by now, it's that what you don't know can hurt you. Laboratory techniques for identifying and measuring contaminants have become several orders of magnitude more precise in the past decade. However, in the time it takes to obtain a sample, transport it to a laboratory, and conduct the appropriate tests, it may already be too late to protect people from harmful exposure or to remedy an emergency situation. For this reason, EPA's researchers have been in the forefront of adopting advanced technologies to produce environmental monitoring devices which can be transported to the scene of a problem or can actually be carried by individuals.

New electronics technology lies at the forefront of this concerted effort. Forging new tools that take advantage of scientific discovery and invention is vital in EPA's ability to solve old problems and to keep one step ahead of new ones.


BLOCK DIAGRAM OF A GAS CHROMATOGRAPH SYSTEM
sample gas
capillary column
regulator
carrier gas
sample injection valve
thermal conductivity detector
output chart recorder
miniaturized part of system

Miniature Gas Chromatograph

A worker in a synfuels plant is walking through an area known to contain certain noxious gases, but generally well below levels known to cause any adverse effects. Suddenly, however, a small alarm sounds. Quickly the worker removes a small device from his belt and checks the display for levels of each of ten gases, then leaves the area, warning others of the danger.

While this scenario can't happen today, it may happen within a few years due to an ingenious, miniature gas chromatograph currently in the final stages of development. The National Institute of Occupational Safety and Health (NIOSH) which was funded, in part, through the EPA-managed Interagency Energy/Environment Research and Development Program, has designed just such a system for personal monitoring of noxious or toxic fumes originating from synfuel plants and other energy-related sources. Weighing just a shade over a pound, the device consists of a chromatograph made up of a capillary column, a sample injection valve, and a detector. A state-of-the-art integrated circuit microcomputer is included to handle control and data processing functions. The gas chromatograph is capable of sampling the atmosphere automatically once a minute for eight hours on a single battery charge, and of measuring the concentrations of up to ten different vapors simultaneously to within 10% accuracy. Concentrations are measured at the 10 parts per million level; time-weighted averages and peak concentrations for each of the gases are calculated and stored—to be displayed on demand—and an alarm sounds for the worker if any concentrations exceed a predetermined value.

The advantage of this personal monitoring approach over traditional factory monitoring approaches is significant. Where in the past samples were collected, enriched, then sent to the laboratory for chemical analysis, the miniature unit allows the worker to respond instantly to any potentially hazardous levels of exposure. It also allows more rapid control over the sources of such environmental pollution.

The miniature gas chromatograph being used to detect leaks in gas canisters

Application of the miniature gas chromatograph is by no means limited to energy production facilities. It can be programmed, for example, to measure simultaneously six (two current and four anticipated) air pollutants that come under the national emission standards for hazardous air pollutants (NESHAPS) of Section 12-1 of the Clean Air Act. It could be used in law enforcement as a breath analyzer for drunken drivers; it might also have a variety of medical applications and possible military uses, for example, to detect gas warfare.

The gas chromatograph, which is being developed by Stanford University scientists under EPA/NIOSH sponsorship, has a promising commercial future as well. More than a dozen private industries and government agencies have already expressed intense interest in the unit, in addition to inquiries from half a dozen foreign countries. The key developers of this innovative device are now in the process of refining the instrument and investigating alternative production options. Thus, in addition to creating an extremely useful monitoring device, our sponsorship may have contributed to the development of a new commercial enterprise.

1980 saw the testing of an 8-pound prototype of the miniature gas chromatograph expected to be available by 1983. Beyond reducing size, further work will extend the sensitivity of the device, ultimately, it is expected, allowing for measurement of ambient air at the high parts per *billion* level.

Carbon Monoxide Monitors Walk City Beat

In Los Angeles, a woman walks by with what looks like a small purse dangling from a shoulder strap. In fact, she is carrying a portable carbon monoxide (CO) monitor, part of an EPA study to determine the feasibility of this unique and mobile method for measuring street-level CO concentrations. Conventional urban air monitoring devices are usually located on the roofs of buildings. These portable monitors will more accurately reflect the exposure of city workers and dwellers to this colorless, odorless, and potentially dangerous gas as they ride in cars or buses, walk across parking lots, or otherwise carry on their business.

The study will be performed by nine subjects in metropolitan Los Angeles. The nine will be selected from among drivers and other people spending time in traffic where they may be exposed to elevated levels of CO created in the combustion of gasoline, oil, and other carbon-based fuels. The study will determine how people react to carrying the monitors, how the monitors themselves behave in a variety of situations and temperatures, and what problems exist in operating them.

Based on the results of this study, a far larger study may be designed involving several hundred subjects in urban locations around the country. Ultimately, it is hoped that such a network of portable monitors will be used to map CO distribution among the entire urban population.

In a related project, EPA researchers have developed a miniature data log that will be used by the subjects in the personal monitoring CO exposure study. The object of the research was to develop a device straightforward enough to be used by an untrained individual, yet complex enough to record, process, and integrate a heavy load of exposure data.

Several prototype devices built in 1980 were designed to process exposure data during periods of specific individual activities. Where in the past such devices would require 1440 one-minute readings per day to be gathered and processed, the most successful prototypes required only 10 to 20 readings over specific periods of activity, resulting in fewer than 30 readings over a 24-hour span.

Fewer readings and easier-to-operate equipment will result, it is expected, in faster data analysis, more efficient quality control, and greater public involvement in the Agency's monitoring programs.

The portable CO monitor

Sensors for the PEARL II system take neurophysiological measurements

A Portable Laboratory Performs Key Tests

Laboring in an orange grove, a number of migrant farm workers suddenly fall ill. Working at an abandoned hazardous waste site, clean-up personnel claim dizziness, nausea. Today, a portable field-testing system developed for EPA's research office by the University of Illinois will allow EPA scientists to travel to where such problems arise and make neurophysiological measurements on humans exposed to various environmental pollutants.

Known as the PEARL II system, this portable neurophysiology laboratory administers a battery of electrophysiological tests of sensorimotor and cognitive functions. Specific tests include the brainstem auditory-evoked response, pattern-reversal visual evoked response, slow potential brain measures of cognitive function, and behavioral measures of reaction time and signal detection. The system also allows for the recording of EEGs, EOGs, EKGs and other vital individual data, much of which can be clinically interpreted on the spot. With data stored on cassette tapes, statistical analyses can be performed at computer facilities at a later time.

The PEARL II system, currently being field tested, could be used in a variety of field environments including hospitals, county health and industrial facilities, and community centers. With this unit EPA will be able to respond quickly to environmental emergencies, and once there, gather vital decision-making, and possibly life-saving information.

Matters of Interpretation

Rather than replace the human photo interpreter with a temperamental, complex automated system, EPA investigators have chosen instead to augment the human eye and brain and power of reasoning with a new photo interpreting tool that is both highly practical and vastly more productive than the photo interpreting tools used in the past.

This image analysis system (IAS), to be used in support of EPA's extensive environmental monitoring responsibilities, permits the journeyman interpreter to transfer data from a photographic image directly onto a geodetic map. It also provides for a method to measure the area and volume of irregularly-shaped natural and man-made phenomena—lakes, power plant plumes, waste sites, or land masses. The work is accomplished by a computer linked to an imagery interpretation light table. Up to five stations may use this computer simultaneously.

The imagery analysis system is capable of providing more comprehensive information and is considerably faster, and far more accurate, than traditional photo interpretation techniques. The older systems also require far more personnel in their operation—interpreters, clerks, draftsmen—than the one-person IAS operation. In fact, a single photo interpreter using the imagery analysis system can take a project all the way from a raw image to the delivery of information to an environmental decision maker in a fraction of the time while producing from five to ten times more data than can be produced using traditional techniques.

> The imagery analysis system is capable of providing more comprehensive information

The new system will be used in conjunction with other overhead monitoring technology to produce pollution source inventories, locate abandoned hazardous waste sites, evaluate land uses, track the migration of oil and hazardous materials from spill sites, reconnoiter areas for ground inspection teams, gather information from inaccessible areas, and for a variety of other circumstances. It is expected that both EPA's monitoring and its enforcement functions will be significantly enhanced by the wide-scale use of the new system. The system is also attracting the attention of other agencies and organizations involved in overhead monitoring.

A photo interpreter at a light table can process data faster and more completely with the imagery analysis system

Disaster Movies

In refinery fires, chemical spills, and other such emergencies, accurate and quickly-gathered information about the nature of the emergency, its extent, and its likely route of spread is crucial to containing and controlling the danger. Unfortunately, to get that information often meant that firemen or other emergency personnel risked their lives; toxic fumes, explosions, or caustic vapors are all too common in accidents at today's industrial complexes. In the future, however, as the result of EPA-sponsored research, the information may be gathered by machine, doing away with the risk to personnel safety and, at the same time, gathering a greater amount of more accurate data. The machine is a remotely controlled hovercraft configured with an on-board camera and powered by an explosion-proof engine, giving it the ability to descend directly into the heart of an emergency.

Development of the hovercraft came about as a result of a long-standing EPA interest in a means to conduct real-time surveillance of hazardous situations and, coincidentally, from inquiries to EPA from the City Council of Oxnard California about such a system. Oxnard, with a population of 80,000, is located about 40 miles northwest of Los Angeles and is the site of a refinery and several chemical plants.

In the initial phase of research, a half-scale hovercraft was designed, built, and tested. The craft carried an on-board movie camera which, during a simulated hazardous materials spill, took film footage that represented the information needed for rapid on-scene emergency decisions. The footage was shown to the Oxnard City Council and other interested parties, and dramatically demonstrated the practicality of the system.

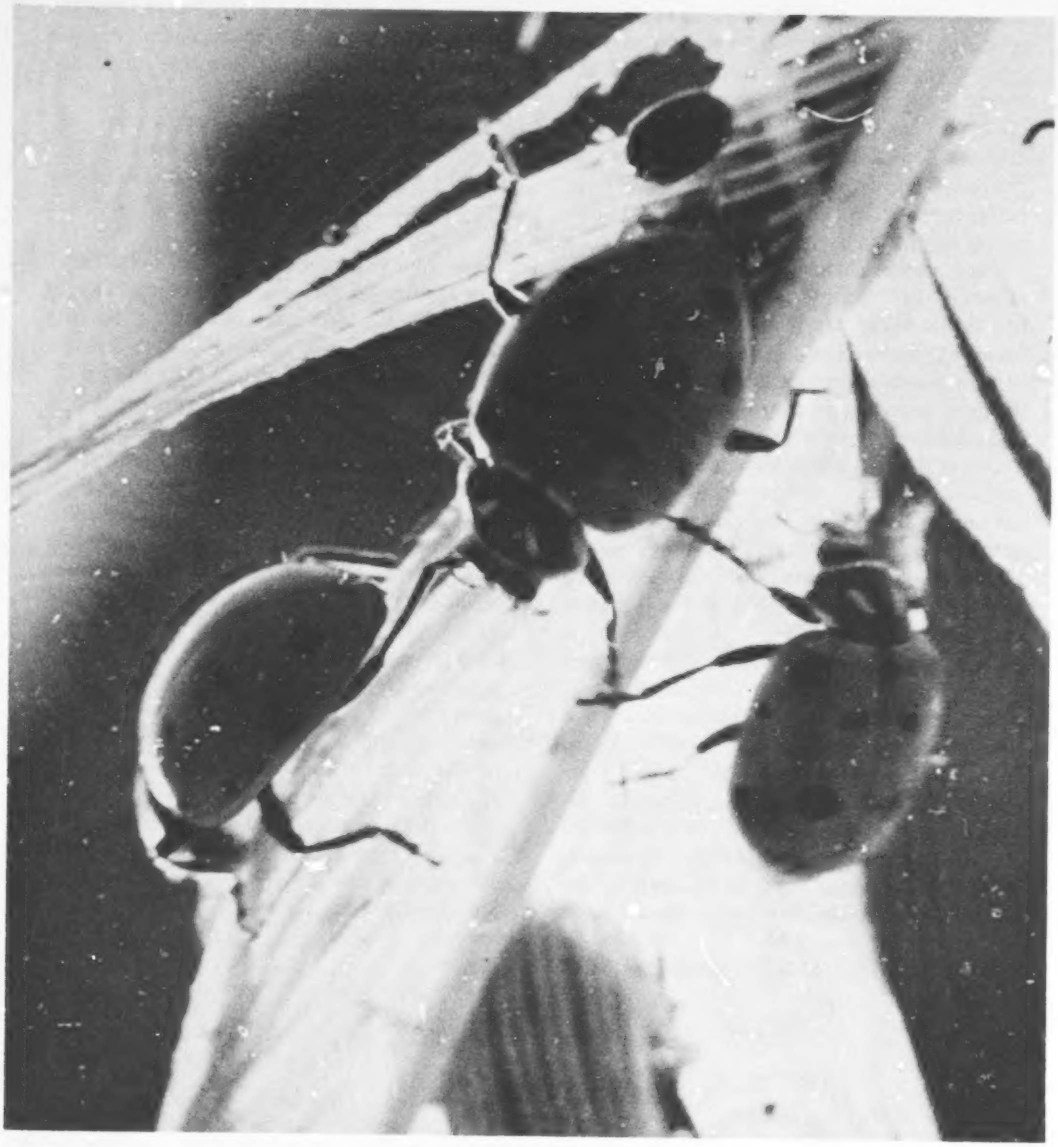
The full-scale system will require, in addition to the TV cameras, a microwave communications link for transmission of the TV signals and for more sophisticated control. It will also require a set of high-energy-density batteries for extra power, and a reduction of its size-to-weight ratio, enabling the full-scale system to fly higher, be more stable and maneuverable than the existing model.

EPA is currently considering the capabilities that would be needed in the proposed full-scale system to meet future surveillance requirements at the sites of hazardous incidents.

The following EPA research components contributed to the research described above:

- Office of Monitoring and Technical Support—Environmental Monitoring Systems Laboratories, Las Vegas and Research Triangle Park
- Office of Environmental Processes and Effects Research, Washington, D.C.
- Office of Health Research—Health Effects Research Laboratory, Research Triangle Park
- Office of Environmental Engineering and Technology—Municipal Environmental Research Laboratory, Cincinnati

INTEGRATED PEST MANAGEMENT



Striking a realistic balance between chemical pesticides and natural pest control methods is a goal of EPA's Integrated Pest Management Program.

Chemical pesticides have long been one of the major weapons available to farmers to control agricultural pests. Farmers using pesticides for the first time often saw their crop yields increase dramatically and their profits do likewise. Pesticides became popular; spraying schedules, dosages, and application patterns became routine; and the cost of the chemicals and their application appeared to be acceptable. Now, however, the cost of pesticides is rising; not only are the chemicals themselves getting more expensive, but the hidden costs of pesticides—dangers to pesticide handlers, hazardous wastes from pesticide production plants, and toxic runoff from farm fields, to name just a few—are becoming more widely recognized as serious problems.

Integrated pest management (IPM) offers an economically and ecologically attractive alternative to the heavy dependence currently put on chemicals to control pests. IPM combines the use of a pest's natural enemies, new farming practices designed to reduce or destroy pest populations, and minimum chemical use.

One of the early classic examples of integrated pest management was the short-season growing of cotton in Texas. This pest-control approach, developed in the late 60s and early 70s, involved altering the growth pattern of cotton plants to shorten the amount of time the cotton was vulnerable to attack by insects. The altered growth pattern reduced the insect threat and the amounts of insecticide used for their control. When the short-season IPM approach was implemented on a broad scale, the results were dramatic. In the Texas coastal area, cotton production went from 56,000 planted acres yielding an average of 200 pounds of lint cotton per acre in 1970 to 255,000 acres with an average yield of 459 pounds per acre in 1979. At the same time, Texas' share of the amount of insecticides used nationwide on cotton dropped from 24% to 2.4%.

EPA's research into IPM has attempted to find equally promising pest control strategies for other U.S. crops in other regions of the country.

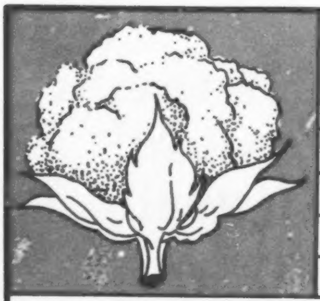
Consortium Founded

Late in 1979, a study was initiated, funded in part by EPA, to develop effective means for applying integrated pest management strategies to major U.S. crops. A consortium for IPM was formed involving more than 250 individual research scientists at sixteen U.S. universities.

A number of projects have already been instituted under the program. One notable 1980 research highlight was the development of a pest management technique for dealing with the alfalfa weevil.

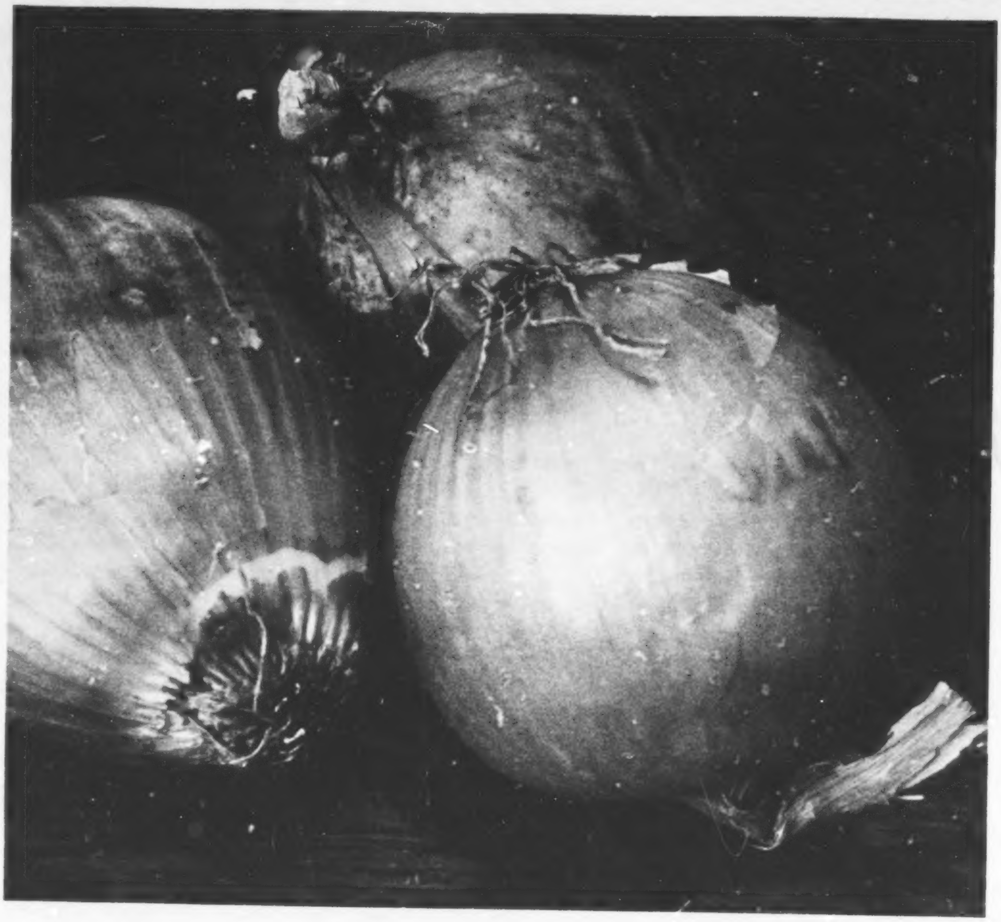
The study demonstrated that rather than spraying toxic pesticides on the entire acreage of alfalfa fields as was done in the past, effective control of the alfalfa weevils can be realized by spraying only a 40- to 60-foot strip around the perimeter of the field. This spraying takes place in the fall as the weevil population crawls back to the alfalfa field from its summer nests. Spraying the perimeter effectively reduces the weevil population before it can disperse throughout the entire field to begin egg laying. Research results also indicate that this reduced pesticide application can also control the clover root curculio, another alfalfa pest with a biological timeclock similar to the alfalfa weevil.

Advantages of this reduced spray method are numerous. In a 30-acre field, only 4 or 5 acres would require spraying. This, in turn, cuts down on the cost of both the chemicals and their application. And because a single spray is applied in the fall of the year rather than in the spring—the traditional time of application—the program does not interfere with planting-time farm operations, nor does it kill beneficial organisms such as parasites of the weevil and birds nesting in the alfalfa.



	before short season	after short season
coastal acres planted	**56,000**	**255,000**
average pounds/acre	**200**	**459**
insecticide use (lbs)	**20 mil.**	**2.3 mil.**
insecticide use (U.S.%)	**24**	**2.4**

RESULTS OF I.P.M. SHORT-SEASON COTTON CROP IN TEXAS



Onion Pests

The more that pesticides are used, the faster users become dependent on them, and the greater the likelihood that their use will result in the inadvertent elimination of natural pest controls. This is but one of the significant findings of an EPA-sponsored IPM project in Michigan, where the study of the onion crop led to a number of 1980 research highlights.

Onions were selected as the focus of the study because in Michigan they are grown on residual organic soils, the remnants of bogs and river oxbows. These areas are ecological islands, surrounded by mineral soils, making them ideal for studying pest control methods. In addition, the onion crops have had a history of pest problems, of insect pest resistance to pesticides, and of high pesticide usage.

The primary insect pest studied was the onion maggot; also studied were a root-knot nematode (a roundworm), a beneficial fungus, *vesicular-arbuscular mycorrhizae,* and diseases common to the crop.

A 1980 highlight of the program was the discovery of a third generation of the onion maggot, which occurs following the onion harvest, but before the onset of winter. This post-harvest generation matures in fall soils and provides the starting maggot populations for the following growing season. Significantly, the entire life cycle of this generation occurs on those onions that are either missed by harvesting machines or are too small to be mechanically harvested; approximately 400-500 pounds per acre. Post-harvest management of these onion culls could have a significant impact on the following year's maggot population.

Onion maggots were the focus of two other research highlights. In one study, results indicated that the fungal disease, *Entomophthora muscae,* which attacks and kills adult onion maggots, was quite sensitive to the fungicides routinely used by growers to reduce the number of pathogens attacking the onion plant. Currently under investigation is the feasibility of timing fungicide applications to accommodate *E. muscae* occurrence. The second onion maggot research highlight involved the discovery of a minute wasp, *Aphaereta pallipes*, and a beetle, *Aleochera bilineata*, that parasitize onion maggot larvae.

A key finding of the root-knot nematode research was that onion fields in Michigan with the greatest input of pesticides and commercial fertilizers consistently had the highest nematode population. It was rare, on the other hand, to find any plant parasitic nematodes at all on those farms where "organic" practices were the rule. Still, many commercial growers in the state routinely spent $100 per acre to fumigate onion fields for nematodes before rotating their fields for carrot cropping.

Other notable conclusions drawn from the work to date include:

- pesticides reduce the potential for pest control by natural enemies;
- by decreasing the use of pesticides, natural enemies of the onion maggot can become abundant in two years;
- commercial onion crops can be grown in the absence of pesticides; and
- weak, malnourished soils are more susceptible to pest attack than are healthy soils.

Overriding all these findings and conclusions is one repetitive biological pattern: As more man-made chemicals are applied to crops and the soil, less of the natural biological balance is maintained.

Riceland Mosquitoes

Among the largest man-made breeding grounds for mosquitoes are those lands devoted to the production of rice. The hordes of mosquitoes coming out of these wetland areas are not only a nuisance, but are sometimes also carriers of disease to humans and domestic animals. Environmentally sound solutions to riceland mosquito problems are beginning to evolve in a number of rice-growing states.

A major 1980 accomplishment of the EPA-sponsored program was the development of a small aquatic sampling device capable of providing researchers with data on the location and abundance of mosquito larvae and on the status of natural mosquito predator populations in a given area. With this information in hand, pest managers can then determine whether control measures will be necessary to suppress the mosquito threat. Tests of the device in a variety of field conditions are currently underway.

1980 also saw major inroads in the use of remote sensing technology as a riceland mosquito survey technique. Researchers worked to develop methods for using aerial infrared photography to detect those habitat conditions preferred by egg-laying females. If these sites can be identified, targeted controls may be possible.

In 1980, significant progress was also made in the use of both non-chemicals and chemicals for control of riceland mosquitoes. For the non-chemical approaches, two mosquito enemies were evaluated for use in the rice fields—a nematode, *Romanomermis culicivorax*, which is capable of infecting mosquito larvae, and a mosquito-eating fish species, *Gambusia affinis*. Research efforts for both of these organisms were on methods to grow enough of them to be an effective mosquito control option.

Results of the research on chemical controls pointed to the beneficial possibilities offered by a toxic chemical produced by the bacteria *Bacillus thuringiensis* variety *israeliensis*, which

A mosquito trap in a rice field

is capable of controlling mosquito larvae. Preliminary results indicate that the chemical is highly effective against certain species of mosquitoes associated with rice-producing areas in the United States, but causes little or no damage to the other animals in the riceland agro-ecosystem community.

Controls for Corn Soil Insects and Worms

Three insect pests that plague field corn in the Midwest are the rootworm, black cutworm, and wireworm. EPA researchers are attempting to find methods to control these pests with a minimum use of insecticides.

Corn rootworms are the single most serious corn pest in the Midwest. The adult stage feeds on the silks and thus interferes with pollination and seed set; the larval stage, the most damaging of all, feeds on roots of the corn plant. Preventive treatments include crop rotation and insecticide application to the soil. Prior to the EPA study, however, these treatments had been applied with little knowledge as to whether the insect was present, or whether the application of insecticide would provide an economic return. A recent research highlight of the program has been the development of improved sampling methods to better predict the need for taking such control action.

The black cutworm is responsible for 95% of the damage caused by cutworms in Midwest cornfields, doing so in their larval stage by cutting corn plant seedlings off at or below the soil level. EPA research, in its extensive study of this pest and its interaction with corn, has recently developed and evaluated the use of a synthetic sex attractant for the black cutworm as a method of trapping male moths (adult-stage cutworms) in the early spring to predict the severity of the larval infestation to come. Using this technique, researchers successfully predicted a light cutworm year in 1980 because of low moth captures. Such predictions allow a much more sensitive—and conservative—use of chemical pesticides.

Also recently developed and evaluated by ORD was a larval sampling method that involved the placement of bait traps in the fields at planting time. These traps were then checked for cutworms after 3-4 days. Study results indicated that the traps were sensitive enough to capture cutworms in the fields where subsequent damage would occur and that 0.5 to 1 black cutworm per trap is sufficient to have economic impact on the corn yield.

A Data Base for Urban IPM

Generally, pest infestation and the use of pesticides conjure the image of sprawling fields of corn or grain, being dusted by what looks like a World War I biplane, and what sounds like a huge gnat. Pests are, however, quite common to urban areas as well, as is pesticide use.

The development of an integrated pest management program for these areas to reduce dependence on pesticides, to increase pesticide worker safety, to protect the public health, and to put a halt to rising urban pest management costs is, by EPA's reckoning, an ideal solution to the urban pest problem. The major obstacle to such a program is that for it to be effective, vast amounts of information must first be collected, sorted, and then packaged to provide a solid data base from which to operate.

In 1980, EPA compiled an urban IPM data base that includes basic biological information on nearly 700 U.S. urban pests and their natural enemies. A complementary data set, called the IPM Matrix, holds the most up-to-date integrated pest management data. Also part of the bank of information is product data from pesticide manufacturers.

In combination, this information now allows researchers and pest control managers to explore the potential an IPM strategy has for a given urban pest. The National Park Service and the National Arborists Association are among those that have already availed themselves of the data base, and are working to refine and validate its contents.

Biological Control for Urban Shade Tree Pests

Insect species can become pests when environmental balances are upset. These pests may be brought under biological control by introducing into this disturbed environment the pest's natural enemies. Such biological control is then the permanent solution to a particular pest problem, accomplished without the need for chemicals that may pose a hazard to more than the pests themselves.

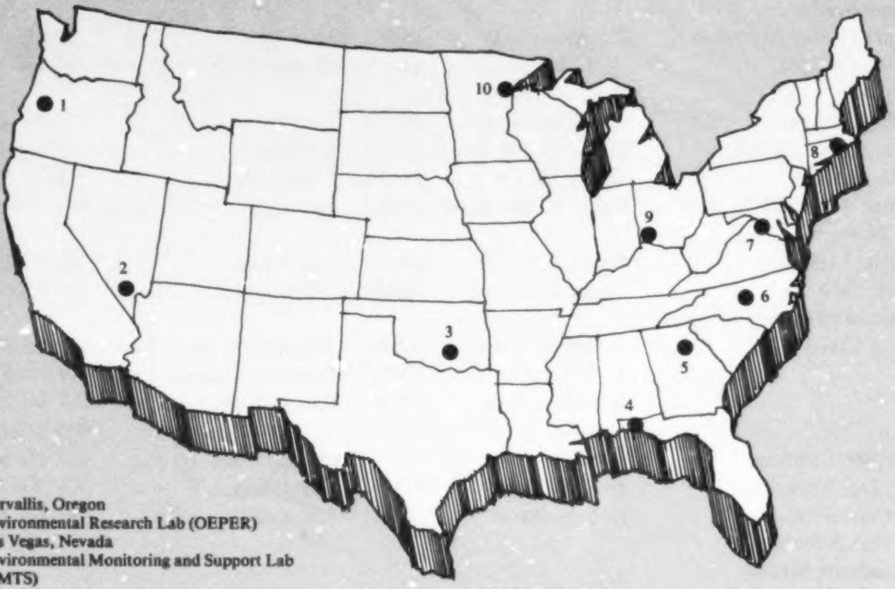
A recent EPA research project has focused on the biological control of a number of pests threatening urban shade trees. The first of these pests, the elm leaf beetle, is the cause of extensive elm tree damage across the entire United States. Researchers in 1980 worked with known parasites of the beetle from the eastern Mediterranean region. The research effort established the parasite species in northern California, the scene of widespread elm leaf beetle damage.

Aphids, too, are frequent pests of shade trees, and reduce the trees' vigor. In 1980, three parasitic miniwasps, each specific to the aphid of a particular tree, were imported and tested on infected trees. Once exposed to the aphids, the wasps were successful in controlling the aphid population. Other importations are currently being planned.

The following EPA research components contributed to the research described above:
- Office of Environmental Processes and Effects Research, Washington, D.C.

ORD RESOURCES

ORD Laboratories



1 Corvallis, Oregon
Environmental Research Lab (OEPER)

2 Las Vegas, Nevada
Environmental Monitoring and Support Lab (OMTS)

3 Ada, Oklahoma
Robert S. Kerr Environmental Research Lab (OEPER)

4 Gulf Breeze, Florida
Environmental Research Lab (OEPER)

5 Athens, Georgia
Environmental Research Lab (OEPER)

6 Research Triangle Park, N.C.
Environmental Monitoring and Support Lab (OMTS). Industrial Environmental Research Lab (OEET). Environmental Sciences Research Lab (OEPER). Health Effects Research Lab (OHR)

7 Washington, D.C.
Headquarters, OR&D

8 Narragansett, Rhode Island
Environmental Research Lab (OEPER)

9 Cincinnati, Ohio
Environmental Monitoring and Support Lab (OMTS). Industrial Environmental Research Lab (OEET). Municipal Environmental Research Lab (OEET). Health Effects Research Lab (OHR). Center for Environmental Research Information (ORPM)

10 Duluth, Minnesota
Environmental Research Lab (OEPER)

Funding for Fiscal 80—
333.9 million, 1850 people

Funding by Media	**$M**
Air	65.6
Water Quality	63.9
Drinking Water	21.8
Solid Waste	12.4
Pesticides	12.6
Radiation	2.9
Interdisciplinary	21.8
Toxic Substances	23.0
Energy	100.6
Management & Support	9.3
Total	**333.9**

Funding by Category	**$M**
Health Effects	83.8
Ecological Effects	43.3
Transport & Fate	23.4
Monitoring	47.8
Control Technology	111.9
Other	23.7
Total	**333.9**

Funding by Mechanism	**$M**	
Contracts	98.8	(30%)
Grants	82.0	(24%)
Interagency Agreements	49.0	(15%)
In-House	104.1	(31%)
Total	**333.9**	**(100%)**

THE PEOPLE

Subject	Contact	Organization	Telephone
Emergencies			
Jacksonville, Arkansas	David McNelis	EMSL—Las Vegas	702 736-2969
Ixtoc Oil Spill	W. P. Davis or P. F. Sheridan	ERL—Gulf Breeze, Fla.	803 559-5886
Mt. St. Helens	David McNelis	EMSL—Las Vegas	702 736-2969
Georgetown, Texas	Edwin C. Lippy	HERL—Cincinnati	513 684-7226
	Elmer Akin	HERL—Cincinnati	513 684-7218
Three Mile Island, Pennsylvania	Erich W. Bretthauer	EMSL—Las Vegas	702 736-2969
Globe, Arizona	David McNelis	EMSL—Las Vegas	702 736-2969
Islip, New York	Frank Freestone	MERL—Edison, N.J.	201 321-6632
Hazardous Waste Disposal			
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	T. R. Hauser	EMSL—Research Triangle Park	919 541-2106
	Steve Bomberg	EMSL—Research Triangle Park	919 541-2106
	Jack Keeley	RSKERL—Ada, Okla.	405 332-8800
On-Site Cleanup	Ira Wilder	IERL—Edison, N.J.	201 321-6635
Sealing Waste Sites	Donald E. Sanning	MERL—Cincinnati	513 684-7871
Technical Data for Permit Writers	N. Schomaker	MERL—Cincinnati	513 684-7871
Standards Setting			
Cancer Risks	Marie Pfaff	HQ/Washington, D.C.—OHEA	202 755-0650
	Elizabeth Anderson		202 755-3968
	John Fowle		202 426-2275
Dioxin Data	David R. Watkins	IERL—Cincinnati	513 684-4481
Burning Hazardous Wastes	Tim Oppelt	IERL—Cincinnati	513 684-4417
Special Treatment	William A. Cawley	IERL—Cincinnati	513 684-4438
Toxaphene Risks	Lee A. Mulkey	ERL—Athens, Ga.	404 546-3581
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	David Reisman		202 426-2275
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Air Pollution			
Inhalable Particulate Monitors	Charles Rodes	EMSL—Research Triangle Park	919 541-3076
Plant Monitors	Shahbeg Sandhu	HERL—Research Triangle Park	919 541-3850
Hazy Blob Movie	William E. Wilson	ESRL—Research Triangle Park	919 541-2551
Lost Vistas	Robert N. Snelling	EMSL—Las Vegas	702 798-2368
MAP3S/RAINE	Jeremy Hales	Pacific Northwest National Laboratory—Richland, Wash.	509 376-7990
Plume Tracking	William E. Wilson	ESRL—Research Triangle Park	919 541-2551
Wastewater			
ORD and Industry Cooperation	Donald E. Francisco	IERL—Research Triangle Park	919 541-2547
Combined Industrial/ Municipal Treatment	Leon Myers	RSKERL—Ada, Okla.	405 332-8800
Organics Analysis	Arthur W. Garrison	ERL—Athens, Ga.	404 546-3453
Predicting Agricultural Runoff	Thomas E. Waddell	ERL—Athens, Ga.	404 546-3560
Energy			
Wood for Home Heating	Mike Osborne	IERL—Research Triangle Park	919 541-3996
Mutagenic Diesel Exhaust	James R. Smith	HERL—Research Triangle Park	919 541-2909
	Joellen L. Huisingh	HERL—Research Triangle Park	919 541-3849

Subject	Contact	Organization	Telephone
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Coal Cleaning	David A. Kirchgessner	IERL—Research Triangle Park	919 541-4021
Coal Wastes as Fishing Reefs	Julian Jones	IERL—Research Triangle Park	919 541-2915
ORD Provides Support	J. David Mobley	IERL—Research Triangle Park	919 541-2915
Converting Oil and Coal to Gas	Samuel L. Rakes	IERL—Research Triangle Park	919 541-2825
Japanese NO_X Control	J. David Mobley	IERL—Research Triangle Park	919 541-2915
Automated Sulfur Removal	Bruce Harris	IERL—Research Triangle Park	919 541-2557
Precipitator Dilemma	Leslie E. Sparks	IERL—Research Triangle Park	919 541-2925
Energy from One Plant to Another	Theodore G. Brna	IERL—Research Triangle Park	919 541-2683
Oil and Gas From Coal			
Gasification Data from Foreign Sources	Ronald Patterson	ESRL—Research Triangle Park	919 541-3779
	William J. Rhodes	IERL—Research Triangle Park	919 541-2852
	T. Kelley Janes	IERL—Research Triangle Park	919 541-2852
Synfuels Air Pollution Controls	Ronald Patterson	ESRL—Research Triangle Park	919 541-3779
Yugoslavian Coal Gasification	Ronald Patterson	ESRL—Research Triangle Park	919 541-3779
Identification of Potential Synfuels Pollutants	William J. Rhodes	IERL—Research Triangle Park	919 541-2853
	N. Dean Smith	IERL—Research Triangle Park	919 541-2708
Health Effects			
Genetic Damage to the Embryo	James Allen	HERL—Research Triangle Park	919 541-2518
Measuring Genetic Damage	Martha Moore	HERL—Research Triangle Park	919 541-3933
Systemic Effects of Common Air Pollutants	Judith A. Graham	HERL—Research Triangle Park	919 541-2531
Cells Unaffected by Microwaves	Carl Blackman	HERL—Research Triangle Park	919 541-2541
Testing Volatile Agents	Stephen Nesnow	HERL—Research Triangle Park	919 541-3847
Modeling			
New Assessment Procedure	James W. Falco	ERL—Athens, Ga.	404 546-3138
Center for Water Quality Modeling	Thomas O. Barnwell	ERL—Athens, Ga.	404 546-3175
Real Terrestrial Life	J. Gile	ERL—Corvallis, Ore.	503 757-4849
Reference Shrimp	Allen D. Beck	ERL—Narragansett	401 789-1071
New Technology			
Miniature Gas Chromatograph	James T. Stemmle	HQ/Washington, D.C.—OEPER	202 426-0265
	Laurence Doemeny	NIOSH—Cincinnati	513 684-4266
Carbon Dioxide Monitors Walk City Beat	David T. Mage	EMSL—Research Triangle Park	919 541-2106
A Portable Laboratory Performs Key Tests	David Otto	HERL—Research Triangle Park	919 541-2601
Matters of Interpretation	Gordon E. Howard	EMSL—Las Vegas	702 798-3110
Disaster Movies	John Brugger	MERL—Edison, N.J.	201 321-6634
Integrated Pest Management			
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